MOTION PICTURES AND YOUTH

CHILDREN'S SLEEP

MOTION PICTURES AND YOUTH

THE PAYNE FUND STUDIES

W. W. CHARTERS, CHAIRMAN

MOTION PICTURES AND YOUTH: A SUMMARY, by W. W. Charters, Director, Bureau of Educational Research, Ohio State University.

Combined with

GETTING IDEAS FROM THE MOVIES, by P. W. Holaday, Director of Research, Indianapolis Public Schools, and George D. Stoddard, Director, Iowa Child Welfare Research Station.

MOTION PICTURES AND THE SOCIAL ATTITUDES OF CHILDREN, by Ruth C. Peterson and L. L. Thurstone, Department of Psychology, University of Chicago.

Combined with

THE SOCIAL CONDUCT AND ATTITUDES OF MOVIE FANS, by Mark A. May and Frank K. Shuttleworth, Institute of Human Relations, Yale University.

THE EMOTIONAL RESPONSES OF CHILDREN TO THE MOTION PICTURE SITUATION, by W. S. Dysinger and Christian A. Ruckmick, Department of Psychology, State University of Iowa.

Combined with

MOTION PICTURES AND STANDARDS OF MORALITY, by Charles C. Peters, Professor of Education, Pennsylvania State College.

CHILDREN'S SLEEP, by Samuel Renshaw, Vernon L. Miller, and Dorothy Marquis, Department of Psychology, Ohio State University.

MOVIES AND CONDUCT, by Herbert Blumer, Department of Sociology, University of Chicago.

THE CONTENT OF MOTION PICTURES, by Edgar Dale, Research Associate, Bureau of Educational Research, Ohio State University.

Combined with

CHILDREN'S ATTENDANCE AT MOTION PICTURES, by Edgar Dale.

MOVIES, DELINQUENCY, AND CRIME, by Herbert Blumer and Philip M. Hauser, Department of Sociology, University of Chicago.

BOYS, MOVIES, AND CITY STREETS, by Paul G. Cressey and Frederick M. Thrasher, New York University.

HOW TO APPRECIATE MOTION PICTURES, by Edgar Dale, Research Associate, Bureau of Educational Research, Ohio State University.

CHILDREN'S SLEEP

A SERIES OF STUDIES ON THE INFLUENCE OF MOTION PICTURES; NORMAL AGE, SEX, AND SEASONAL VARIATIONS IN MOTILITY; EXPERIMENTAL INSOMNIA; THE EFFECTS OF COFFEE; AND THE VISUAL FLICKER LIMENS OF CHILDREN

SAMUEL RENSHAW
PROFESSOR OF EXPERIMENTAL PSYCHOLOGY
OHIO STATE UNIVERSITY

VERNON L. MILLER
INSTRUCTOR IN PSYCHOLOGY, BOWDOIN COLLEGE
PAYNE FUND RESEARCH FELLOW, 1930–31

DOROTHY P. MARQUIS
N.R.C. FELLOW, YALE UNIVERSITY, 1931–32
PAYNE FUND RESEARCH FELLOW, 1929–30

NEW YORK
THE MACMILLAN COMPANY
1933

THIS SERIES OF TWELVE STUDIES OF THE INFLUENCE OF MOTION PICTURES UPON CHILDREN AND YOUTH HAS BEEN MADE BY THE COMMITTEE ON EDUCATIONAL RESEARCH OF THE PAYNE FUND AT THE REQUEST OF THE NATIONAL COMMITTEE FOR THE STUDY OF SOCIAL VALUES IN MOTION PICTURES, NOW THE MOTION PICTURE RESEARCH COUNCIL, 366 MADISON AVENUE, NEW YORK CITY. THE STUDIES WERE DESIGNED TO SECURE AUTHORITATIVE AND IMPERSONAL DATA WHICH WOULD MAKE POSSIBLE A MORE COMPLETE EVALUATION OF MOTION PICTURES AND THEIR SOCIAL POTENTIALITIES

Set up and printed from type. Published July, 1933.

PRINTED IN THE UNITED STATES OF AMERICA

TO

THE 170 BOYS AND GIRLS

WHOSE CHEERFUL AND WILLING COÖPERATION

HAS MADE THESE STUDIES POSSIBLE

CHAIRMAN'S PREFACE

Motion pictures are not understood by the present generation of adults. They are new; they make an enormous appeal to children; and they present ideas and situations which parents may not like. Consequently when parents think of the welfare of their children who are exposed to these compelling situations, they wonder about the effect of the pictures upon the ideals and behavior of the children. Do the pictures really influence children in any direction? Are their conduct, ideals, and attitudes affected by the movies? Are the scenes which are objectionable to adults understood by children, or at least by very young children? Do children eventually become sophisticated and grow superior to pictures? Are the emotions of children harmfully excited? In short, just what effect do motion pictures have upon children of different ages?

Each individual has his answer to these questions. He knows of this or that incident in his own experience, and upon these he bases his conclusions. Consequently opinions differ widely. No one in this country up to the present time has known in any general and impersonal manner just what effect motion pictures have upon children. Meanwhile children clamor to attend the movies as often as they are allowed to go. Moving pictures make a profound appeal to children of all ages. In such a situation it is obvious that a comprehensive study of the influence of motion pictures upon children and youth is appropriate.

To measure these influences the investigators who cooperated to make this series of studies analyzed the problem

to discover the most significant questions involved. They set up individual studies to ascertain the answer to the questions and to provide a composite answer to the central question of the nature and extent of these influences. In using this technique the answers must inevitably be sketches without all the details filled in; but when the details are added the picture will not be changed in any essential manner. Parents, educators, and physicians will have little difficulty in fitting concrete details of their own into the outlines which these studies supply.

Specifically, the studies were designed to form a series to answer the following questions: What sorts of scenes do the children of America see when they attend the theaters? How do the mores depicted in these scenes compare with those of the community? How often do children attend? How much of what they see do they remember? What effect does what they witness have upon their ideals and attitudes? Upon their sleep and health? Upon their emotions? Do motion pictures directly or indirectly affect the conduct of children? Are they related to delinquency and crime, and, finally, how can we teach children to discriminate between movies that are artistically and morally good and bad?

The history of the investigations is brief. In 1928 William H. Short, Executive Director of the Motion Picture Research Council, invited a group of university psychologists, sociologists, and educators to meet with the members of the Council to confer about the possibility of discovering just what effect motion pictures have upon children, a subject, as has been indicated, upon which many conflicting opinions and few substantial facts were in existence. The university men proposed a program of study. When Mr. Short appealed to The Payne Fund for a grant to support such an investigation, he found the foundation receptive

because of its well-known interest in motion pictures as one of the major influences in the lives of modern youth. When the appropriation had been made the investigators organized themselves into a Committee on Educational Research of The Payne Fund with the following membership: L. L. Thurstone, Frank N. Freeman, R. E. Park, Herbert Blumer, Philip M. Hauser of the University of Chicago; George D. Stoddard, Christian A. Ruckmick, P. W. Holaday, and Wendell Dysinger of the University of Iowa; Mark A. May and Frank K. Shuttleworth of Yale University; Frederick M. Thrasher and Paul G. Cressey of New York University; Charles C. Peters of Pennsylvania State College; Ben D. Wood of Columbia University; and Samuel Renshaw, Edgar Dale, and W. W. Charters of Ohio State University. The investigations have extended through four years, 1929–1932 inclusive.

The committee's work is an illustration of an interesting technique for studying any social problem. The distinctive characteristic of this technique is to analyze a complex social problem into a series of subordinate problems, to select competent investigators to work upon each of the subordinate projects and to integrate the findings of all the investigators as a solution of the initial problem. Such a program yields a skeleton framework, which, while somewhat lacking in detail, is substantially correct if the contributing investigations have been validly conducted. To provide this framework or outline is the task of research. To fill in the detail and to provide the interpretations are the natural and easy tasks of those who use the data.

W. W. C.

Ohio State University
June, 1933

AUTHORS' PREFACE

In this monograph we offer the first extensive quantitative data on the sleeping habits of children of the ages six to eighteen. The work represents a part of a larger and related group of investigations of the influence of motion pictures on children, sponsored by the Payne Fund, of New York.

Our particular problem centers around the question as to whether or not moving pictures of various sorts produce effects which alter the pattern of sleep in a way prejudicial to normal health and growth. Sleep motility was used as the indicating function because it can be measured quantitatively and because it permits an examination of the influence which waking impressions may have in delaying the appearance of the more or less complete relaxation and escape from the waking world in sound sleep. New use has thus been made of a very old psychological principle in examining the nature and amount of the change in children's sleep after seeing motion pictures as compared with their own normal sleep patterns.

In order to assist in the interpretation of these comparisons we have made certain additional studies on other agents which are also capable of influencing sleep.

Our studies have met with the difficulties which are inevitable to any pioneering investigation. The literature was found to contain practically no previous work on children's sleep and motion-picture effects to guide us, so we were forced to let the accumulated results dictate the next steps throughout the series of experiments.

It is obviously impossible to print here the complete and

detailed tabular records of each experiment. These records include a tabulation of over three and a half million minutes of sleep given by 170 different children. We have included in tabular and graphic form enough of the findings to bring out the important developments and to indicate the manner of arriving at the conclusions which, in our best judgment, we were able to draw from the data. We are not unmindful of the incompleteness and of the desirability for further work in many parts of this report.

We have striven to adhere to a viewpoint as objective and impartial as possible in our handling of the movie problem. There has been neither desire nor coercion to bring in one sort of finding accentuated at the expense of other possibilities. This has been a most pleasant aspect of our relations to the donors and sponsors of the project.

ACKNOWLEDGMENTS

IT is difficult to express accurately our obligations to all those who have materially helped us. We are indebted to Dean G. F. Arps and Dr. W. W. Charters, for they were largely instrumental in bringing us into the series of studies; also for their advice and counsel on many occasions.

Dr. C. H. Calhoon, director of the Ohio Bureau of Juvenile Research, permitted us to use the children and facilities of the Bureau. Dr. C. H. Growdon and Mr. F. P. Bakes assisted in the selection of the subjects and furnished the histories and clinical data on individual children. Dr. J. M. Gettrost, resident physician, in addition to many personal and professional kindnesses, ran eighty basal metabolism tests for us in one part of the work. Mrs. Margaret Gage and Miss Doris LaFollett, in charge of the boys' and girls' cottages, gave much of their time to the details of managing the children according to our plans. Our debt

to the entire Bureau staff can hardly be expressed adequately here.

Drs. Robert F. Wallace, F. Hillis Lumley, and Robert H. Bruce assisted the senior writer in the development of the apparatus and in the tryout in Experiment I. Miss Shonette W. Meyer contributed to the analysis of the movie data, and Miss Leona Chidester made the study of changes in the sleep pattern before illness. Mr. Pearl Manring was in constant nightly attendance with the apparatus for more than 300 nights of ten hours each. His protocols have been most helpful.

Dr. Dorothy P. Marquis served as Payne Research Fellow during the year 1929–1930. It was with her help that the general planning and execution of the first five experiments were completed. Mrs. Eleanor Hyde Martin was the research assistant during the year 1930–1931. Her study of seasonal variations, being part of Chapter V, and her computational work were invaluable. Mr. Benjamin E. Carroll put the manuscript into type and aided in the translating of portions of Karger's monograph and in the working over of the data into their present form. To all these persons we are deeply grateful.

We have profited in many ways from the studies on adult sleep by Dr. H. M. Johnson and his associates in the Simmons investigation of sleep at the Mellon Institute. A considerable portion of the argument of Chapter VII, dealing with the interpretation of fatigue states in relation to loss of sleep, was suggested by previous writings of Dr. Johnson on these topics. We include this material with the author's kind permission.

To the following authors and publishers we wish to express out thanks for permission to quote from various works: Harcourt, Brace and Company, New York, for a

statement from Professor Kurt Koffka's *Growth of the Mind;* Dr. Edmund Jacobson and the University of Chicago Press for several excerpts from Dr. Jacobson's *Progressive Relaxation;* Dr. C. N. Rexroad and the *American Journal of Psychology* and Dr. N. Kleitman and the *Physiological Reviews* for quotations from articles appearing in those journals; and the S. Karger Press and Dr. P. Karger, of Berlin, for permission to render into English a portion of the study on children's sleep which appeared in the 1925 volume of *Jahrbuch für Kinderheilkunde.* Complete references to all citations will be found in the text and in the bibliography.

Our gratitude to the boys and girls who served as the subjects of our studies is expressed elsewhere in this volume.

THE AUTHORS

Columbus, Ohio
June, 1933

TABLE OF CONTENTS

LIST OF FIGURES

CHILDREN'S SLEEP

CHILDREN'S SLEEP

CHAPTER I

INTRODUCTION TO THE PROBLEM

Ist doch stammesgeschichtlich, gerade umgekehrt zu der Entwickelung des einzelnen Menschen, das Schlafbedürfnis um so geringer, je unentwickelter das Nervensystem ist.—A. PEIPER.

1. INTRODUCTORY SUMMARY

WE present in this monograph the results secured from recording the sleep movements of 170 children of both sexes, ages six to eighteen years, during 347 nights. These children, in groups of twenty, slept in single beds each fitted with an electrical device which recorded the changes in posture made by the sleeper minute by minute throughout the nine hours' stay in bed each night. Each group of twenty children remained in the experimental beds about fifty consecutive nights. Nine experimental groups were studied. Our records include a total of 3,591,000 minutes, or 59,850 hours, or 6650 child-nights of sleep. This is virtually equivalent to seventeen years of 365 nights' sleep on a single child, and represents perhaps the most comprehensive study, in number of subjects and number of observations on each subject, thus far reported.

Our problem was first to determine a satisfactory norm or standard sleep pattern for the various ages, sex groups, and seasons of the year. Knowing this, we could then compare with this value the sleep patterns obtained after the children saw various types of motion pictures in a typical neighborhood theater. The theory underlying the use of

sleep motility as a measure of possible motion-picture influence is based on the common observation that strong impressions with which we become preoccupied before going to sleep tend to persist and hence delay the onset of relaxed, recuperative sleep.

We present the results of exposing various groups of the children to a total of fifty-nine different motion-picture programs. Data are also shown to illustrate the variations in sleep motility with the season; the effect of coffee and coffee-substitute drinking at the evening meal on sleep motility; the effect of loss of sleep, produced by a 30 per cent reduction in the habitual sleep ration; the alteration of the sleep pattern in impending illness; and a study of the limens of critical frequency for visual flicker in children of various ages—a problem undertaken with the view to determining the truth or falsity of the opinion that movies may cause eyestrain because of the flickering light.

The nine experiments described herein were conducted over a period of about two and one half academic years. The monograph includes a summary of previous work upon the problem of sleep in childhood, and a bibliography of 255 titles on the general aspects of the problem.

2. THE GENERAL SETTING OF THE PRESENT INVESTIGATION

EARLY in 1929 Dr. W. W. Charters discussed with Dean George F. Arps, Chairman of the Department of Psychology at Ohio State University, the proposed group of studies of the influence of motion pictures on various aspects of child health and development. At the suggestion of Dr. Arps the senior writer was invited to consider the problem with reference to the contributions which could be made from the experimental psychological laboratory.

Six years before, an apparatus had been constructed

(45), and a series of experiments made, for studies on the extent to which changes in human posture are related to efficiency of performance in the early stages of the acquisition of skill. In these studies the subject was seated on a chair, mounted on a triangular platform on ball bearings in such a fashion that any movement, translated through the body's center of mass, was recorded on a polygraph tape. It became apparent that a child's bed could be substituted for the chair, and an apparatus embodying the same principles could be used for studying the postural movements of children during sleep.

Children are reported to sleep less soundly after the reading of, or listening to, fairy tales. Parents have reported clear and unmistakable instances of disturbing effects on the sleeping and waking behavior of children which were attributed to films they had seen. We have sought in these experiments to discover to what extent there is a measurable difference in the sleep pattern of a child incidental to having viewed a motion-picture program in the two-hour period before retiring from that which is his normal characteristic.

In the first chapter of this report we present a brief statement of the theoretical principles involved in using sleep motility as an index of the influence of motion pictures. In subsequent chapters we present, in contrast, the picture of how other variable conditions affect the motility patterns. But first we must ascertain from previous work upon this and related problems what other investigators have found. After gaining some information as to the extent of the variation found under normal living conditions, we then examine the sleep patterns of the same children after they have seen various types of movies. Then, to assist the reader in his own interpretations of our findings, we present the results of studies on an experimental insomnia, and on coffee

drinking. These are common and familiar and may both serve as a basis for the comparative evaluation of the movie data and also give some notion of how these things affect the normal motility curves of children.

Chapters V to VIII should be read carefully as a unit. It will be found that much of the evidence presented in the form of graphs and statistical summaries cannot be reduced to terse and short generalizations. The concluding statements at the ends of the chapters, therefore, do not and cannot tell the whole story.

3. The Psychological Principles Involved in the Use of "Sleep" Measurement in Children as an Index of the Movie Influence

Bodily and mental processes are things "of the earth, earthy." They have an *inertia-effect*. They carry on even after the actor or thinker has changed to a new environment. This renders the persisting response system out of place. A simple experiment can be made to illustrate the point. Lift two weights simultaneously, one heavy and one light. Wear a blindfold, of course. Now, after repeating this several times, have someone transpose the two weights. The muscular "pitch" or "set" carries over and too much power is applied to the lighter of the two weights and too little to the heavier. Our attitudes, beliefs, and sentiments operate in a similar way.

After any prolonged period of preoccupied effort it is difficult, if not impossible, to stop at once and relax or engage in such activity as reading for pleasure, going to sleep, or what not. To the extent that a person becomes preoccupied with any thing or process he becomes proportionately unresponsive (*i.e.*, his thresholds are raised and he is comparatively desensitized) to the rest of his environment.

Sleep is no exception to this class of phenomena. We must remember that it is a *positive* form of human behavior, just as walking or talking. When we seek to change from active waking conduct to sleeping conduct, then, the rapidity and degree of success with which we can escape from the waking environment will depend upon the extent to which after-effects tending to delay the onset of relaxed, recuperative sleep are absent.

In view of these considerations it should be possible to use some reliable measure of sleep or an associated process as an indicator of the magnitude of the total impression made upon a child, by securing such a measure following the viewing of various types of motion pictures. It will be necessary for us to consider some of the things known about sleep, its relation to health and development, and to raise some questions about the normal sleep habits in childhood before we can use some function of sleep as a measure of the change, consequent to seeing a movie, in what Trömner (166) has called *dormition*, —*i.e.*, the characteristic sleep pattern of the individual.

4. SOME QUESTIONS ABOUT NORMAL SLEEP IN CHILDREN AND ADULTS

IN all living things there occur alternate periods of activity and rest. It is not known whether all of these periods of rest differ in kind or only in degree from sleep in man. It is certain, however, that many of the organs and tissues of the body have widely differing periods of rest and activity. This may vary from a short, sharp period of activity and a long, slow period of recovery to that in which these relations are reversed. In the brain, where metabolism is highest [1], there are still gradients in the lessened activity which comes with sleep. The entire cortex does not "sleep" at the same

[1] Cf. Child, C. M., *The Physiological Foundations of Behavior*. New York: Holt, 1924, p. 197.

time, nor always to the same extent. The loss of muscular function, for example, occurs considerably earlier than the diminution or disappearance of sensitivity to touch and sound. On awakening the reverse of these relations holds, otherwise the process of awakening would be far more difficult. The word "sleep" must be understood, therefore, as a classificatory term. It refers to an artificial social description of the organism in respect to its responsiveness to its total environment, and not to the specific description of what functions are ready to react in whole or in part. This statement is exemplified by an experiment of Sherman (51), who asked a number of physicians, nurses, psychologists, and others to look at a baby and tell whether it was *asleep* or *awake*. The wide disagreement among all classes of judges strikingly proved the unsatisfactory character of the term, even as a *social* description.

How much is now known about children's sleep?—One of the writers has examined the existing literature on sleep—the sleep studies on children in particular—found in the Ohio State University Library, the Library of Congress, and the Surgeon General's Library in Washington. The net result of his search gave us an acquaintance with practically every important paper. There are only a few on children's sleep, and we shall summarize them briefly later in this chapter. It is impossible to find in them satisfactory answers to the questions on which we must have definite information in order to compare normal sleep in childhood with sleep after some experimentally controlled variable condition, such as viewing a film, has been introduced. Some of these questions are:

1. Is *motility*, change in posture, or *restlessness*, negatively correlated with sound, recuperative sleep?

2. Is the distribution of active periods, or that of quiet periods, the truer picture of sleep?

3. How does the sleep of younger children differ from that of older ones?

4. Do boys and girls of the same age show significant differences?

5. Are boys and girls equally susceptible to external influences such as activity during the day, movies, drugs, seasonal variation, etc.?

6. Is motility during sleep closely correlated with environmental temperature and humidity?

7. What is the shape of the normal sleep curve for an individual child? Is there a characteristic pattern for the individual? If so, at what age does this become manifest?

8. How many observations (nights' sleep) must one make in order to secure a true picture of the characteristic sleep pattern (if any) of a child or group of children?

9. Is it true that sleep during the fore part of the night has greater recuperative value than that indulged in toward morning?

10. What effect will reduction of the sleep ration have on the characteristic curve?

11. Is motility correlative to "depth of sleep" as revealed by the disappearance of reflexes, changes in circulation, electrical resistance, etc.?

12. Does sleeping in a room with other children change the sleep pattern?

13. How much sleep does a child of a given age need in order to maintain normal health and growth?

14. To what extent does the habit factor play a rôle in children's sleep?

15. Do certain types of motion pictures produce effects which delay the onset of sleep in children? If so, what types?

16. At what age or ages are these effects maximal? Is there a sex difference in this respect?

17. What kinds of changes in motility follow the viewing of different types of motion pictures?

18. To what extent is impairment of the normal sleep pattern prejudicial to health and growth?

5. Previous Studies

One of the most extensive studies of the alternate periods of rest and activity in animals and human beings was made by Szymanski (116). By fitting cages, etc., on suspended springs and attaching these to suitable recording devices he was able to plot *actograms* representing the time of occurrence and the duration of the periods of activity and rest. He reports, among other things, observing eleven human infants, one to ten days of age. Six periods of activity and rest are shown in each twenty-four hours, the former usually occurring at or near the time of feeding. In puppies the number of phases is still greater. This multiple alternation is called *polyphasic* in distinction to the *monophasic* distribution found in adult human beings and in some animals, for example, certain species of serpents.

Irwin (158), using a modification of an apparatus described previously by one of the writers (45), took continuous records on about fifty infants during the first fourteen days of life. There was no such division of the day into diurnal and nocturnal periods as is seen in adult life. His observations corroborated those of Szymanski (116) as well as the previous observations of Peiper (161), Canestrini (146), and Karger (160), in which it was shown that the activity peaks occur at the time for feeding, and that as the feeding routine is changed, the periodicity likewise changes. Wada (118) has asserted that postural shifts or activity of the muscles during sleep is induced by, or associated with, the peristaltic waves, or hunger contractions, of the gastric tract. We shall

present evidence later to show (Chapter V) that nocturnal activity in the children of our investigation does not follow any such physiological periodicity.

Czerny (119) about forty years ago attempted to measure the "depth of sleep" in children by the minimum strength of induction shocks required to awaken them at various times of the night. The shocks were applied as many as ten times per night at intervals of one hour. The number of observations depended on how long the child slept. Czerny's results show two maxima (or periods of lowest irritability), one in the first quarter of the night and one in the fourth quarter. These are separated by a minimum, in which the sensitivity of the waking state is very closely approximated. The results show no evidence of the rhythmic fluctuation of irritability which is strikingly characteristic of the results, as yet unpublished, obtained by Garvey (154) on twelve very young children (two and one half to four years) at the University of Minnesota. Johnson (4) comments upon Czerny's findings in this respect as follows: "This . . . suggests that their rest is disposed to occur in two distinct segments. The interpretation suggests itself that the heightened irritability in the middle of the night is a degraded tendency to awaken for a midnight feeding—a habit set up during the earliest weeks of infancy which persisted for a long time thereafter." In our group of 170 children, aged six to eighteen years, this characteristic is not found to be present, as will be noted from the records to be shown later.

The monograph of Blatz and Bott (143) and the paper of Foster and Goodenough (153) are based upon records kept by mothers of the amount or duration of sleep indulged in by their children, together with observations on the duration of afternoon naps by preschool children,

and contribute little to questions pertaining to nocturnal sleep in childhood. The earlier study of Terman and Hocking (164) was an attempt to find the average length of the stay in bed of children of different ages.

Among the most recent and complete studies on children's sleep are those of Karger (160). His studies are of the clinical or observational type (*Beobachtungsversuchen*). Although he observed children two and one half to twelve years of age, sleeping in beds fitted with the Nagel hypnograph,[2] he makes no quantitative use of his records. Since Karger presents a rather extended discussion of various phases of the problem of sleep and its investigation, in addition to a review and critical comments on previous work in this field, and since his publications are not generally available, we quote the following paragraphs from his monograph.

> *The Quality of Sleep.*—By "quality" of sleep we understand its property of so restoring the fatigued functions of the individual that his full power of action is restored, and the subjective feeling of recovery and of mental and bodily freshness is produced. We know that a short sleep can bring complete refreshment, while an overly long sleep may produce a feeling of languor. The time that the human being spends sleeping depends very essentially upon the nature of his activity, may further be varied by habit, and finally is strongly influenced by environmental factors such as light, heat, and season of the year. The researches of Michelson, among others, show that a summer and a winter type of sleep can be distinguished, not only with respect to depth, but also with respect to duration.
>
> *The Depth of Sleep.*—The depth of sleep was first made the object of experimental investigation by Kohlschütter. He sought to measure it by allowing graduated sound stimuli to operate until the subject in question awoke. He required as

[2] An instrument similar in principle to the seismograph. It is attached firmly to a bedpost and records each stir on a small, slow-moving kymograph. It is manufactured and sold by the Zimmerman Corporation, Leipzig, Germany.

a valid sign of awakening the operation of a signalling device by the subject, a requirement which later investigators, as Mönninghoff and Piesbergen and others, have retained. The investigators in question proceeded on the assumption that of all the sense organs the ear was the last to "go to sleep" and the easiest to "awaken." Kohlschütter asserted further that a summation of subliminal stimuli would not lead to awakening; therefore he could use his graduated stimuli (the falling of a ball from definite heights onto a wooden block) in order thus to determine approximately the threshold stimulus for awakening. . . . Since he worked with adults, many subjects would go to sleep under tensions (*mit Spannungsaffekten*), which would influence the course of sleep, and further, the values found by him on different nights were different; in spite of this he succeeded in establishing usable curves of the depth of sleep. Curves which agreed therewith were obtained by Czerny with children, in securing which he used faradic shocks, precisely measured in milliamperes, as waking stimuli.

Critique of the Investigations on Depth of Sleep.—Michelson, like Canestrini, rightly objects to Kohlschütter's investigations on the ground that subliminal stimuli, even if they do not lead to awakening, still alter the depth of sleep. He assumed as a criterion of awakening slight movements and changes in the type of breathing. All of his adult subjects said that they experienced a feeling of tension at the time of going to sleep. Also Trömner emphasizes that frequently repeated slight stimuli lead to awakening, where a single greater one does not. He criticizes also the usefulness of the concept "waking stimulus" (*Weckreiz*), which is extremely variable, since it is strongly influenced by the expectation of awakening. He points out further that not only are outside events significant, but to a much higher degree inner stimuli, such as a full bladder, pains, diarrhoea, etc. Laache was able later to verify these statements on the basis of clinical observations. The effect of a stimulus-quality depends not only upon its strength, but also, for example, upon its specific affective disposition (*Affektbetonung*). A woman in a maternity ward is usually awakened immediately by the whimpering of her child in the next room, whereas she will sleep on through a heavy storm.

The dependence on the make-up of [the subject's] consciousness is, consequently, in general much too infrequently taken into account with respect to these investigations on adults; it is also not easy to estimate, although, for example, Mönninghoff and Piesbergen in their investigations on themselves found distinctions each according to his manner of life and affective state. Trömner says clearly that in the case of the previous researches the curve of depth of sleep gives no type of normal sleep, but shows its form under the safeguard of experimental conditions. We might add that, on account of the expectation-effects, we might regard the conditions of the experiment less as a safeguard than as a disturbing influence.

All these experimental arrangements are unusable for experimenting on the child, because here the statement of Kohlschütter, that stimulation of the sense of hearing wakes us most easily, does not hold. An observer of sleeping infants obtains no reaction even to the strongest sound stimuli, and this characteristic is retained in the case of many children until after the school age is reached. Easy awakening by auditory stimuli generally distinguishes the neuropathic child. On the other hand, the sensitivity of the child to strong illumination, cold, and pain is very pronounced. Kussmaul was able to show that sleeping newborn infants, upon stimulation by light, tighten the eyelids, while they cannot yet fixate nor follow the light source when awake.

Czerny observed that infants cannot be put to sleep when they are left lying naked, but that they go to sleep very quickly under the protection of a poor conductor of heat. He used, as mentioned, painful faradic shocks for his measurements and in the case of older children saw in continued restlessness of the skeletal musculature, along with opening of the eyes, etc., the criterion of awakening. He did not succeed in making investigations with this method on adult subjects, because they did not go to sleep at all with the electrodes on the arm. For this reason Czerny regards this method as unobjectionable for investigations in the case of children, because with them the influence of the sensorium drops out. We will be able to show in our own experiments that this assumption, at least for the older children, does not hold.

. . . .

Quietness of Sleep and Sleep Movements.—We come . . . upon a further sleep quality which until now has beenvery much neglected: the quietness or restlessness of sleep. And yet restless sleep, that is, sleep rich in movement, is one of the most frequent complaints, next to too light sleep, with which mothers of neuropathic children seek aid from physicians. The relationship between sleep movements and the quality of sleep interests us clinically above all—the quality of sleep in the sense in which we have defined it above. Everyone will know from his own experience that often, when going to sleep is difficult, one throws himself around in bed with completely or almost completely retained consciousness, and feels this as uncomfortable and not at all refreshing. On the other hand, there are people who are accustomed to sleep very well,—that is, they wake up refreshed and fully capable of activity, and then notice that they have disarranged all their bedclothes during sleep. . . . Our experimental children awoke as early as was their habit, even if the bed was in another room and they were not awakened. . . . The relationship of movement during sleep to the duration of sleep is entirely inconstant; apparently no reciprocal dependence exists at all. Perhaps this may also be attributed to the fact that children are easier to accustom to definite times for sleep and definite durations of sleep than are adults, so that perhaps in the case of the latter there will prove to be relations which are reconcilable to law. To us it was most important to study the influence of movements during sleep upon the depth of sleep, for the critical evaluation of the previous research methods.

. . . .

Relation of Movements to Depth of Sleep.—If we regard sleep as a passing, temporary condition of the human being, during which most of the reflexes are decreased or suspended from action (Kronthal), then a sleep is more sound the greater the stimuli which are required in order to release such reflex action. The more easily a body reacts to stimuli, just that much less is it in a condition of rest, and just that much less will be the recovery of the functions, since they are again set to work by very slight, and therefore unavoidable, stimuli.

. . . .

After extended preliminary investigations, we chose light stimuli and tested to ascertain whether the sleeping child tightened his eyelids upon the approach of a light source.

. . . .

During periods when sleep was quiet and at its greatest depth, the lid reactions were obtainable only after very long illumination, even when the light source was brought within a few centimeters of the closed lids. If the experiments were made with restlessly sleeping children shortly before a chance movement during sleep, the reaction showed itself when the light source was more than a meter distant. The same result was obtained shortly after a movement. Soon, however, the former depth of sleep was again established. Whether it was especially deep after this disturbance (Czerny, Kohlschütter, *et al.*) was not always clearly to be distinguished by our method, yet this could oftentimes be observed. With longer illumination there followed avoidance movements of the head, the arms, later of the remainder of the body, and finally awakening. From our series of experiments it develops that sleep becomes appreciably lighter shortly before and shortly after a sleep-movement.

. . . .

Peiper was able to make similar observations in another way. When he tested the psychogalvanic phenomenon in deep sleep, it could not be released. With most children, however, he could find it accompanying sleep-movements. From this it also follows, therefore, that sleep at this time is more superficial. If the children tightened the lids only upon illumination, the galvanic phenomenon did not appear; apparently therefore no measurable change of the depth of sleep is produced by the blinking reaction.

. . . .

Our sleep curves show almost without exception a grouping of movements in the first hour of sleep, that is at the time of its rapidly increasing depth. Clinical observation confirms this finding. Most children throw themselves about considerably [during this first hour or so in bed].

. . . .

Waking can occur suddenly without warning, merely through opening of the eyes, or it may be accompanied by movements. [In the latter case] the children throw themselves about for a considerable time; we see, therefore, with the decreasing depth of sleep as also with the increasing, this same grouping of movements.

. . . .

Conclusions.—The sleep of the child, in addition to varying in depth, as already known, frequently becomes lighter, or more superficial, which is made manifest by the occurrence of movements. The sleep is not interrupted to the point of full wakefulness by these. In addition to the stimulus necessary to awaken, the blinking reaction to light is usable as a test for the measurement of depth of sleep. The registration of the movements makes it evident that only a part of the children show a course of sleep so constant that the results of different nights would be comparable with one another.[3] After an interruption of sleep to the point of waking the period of sleep immediately following is less quiet for some time.[4]

The quietness or restlessness of sleep depends upon the temperament of the child to the extent that a parallelism can be discerned between restlessness of sleep and mental agility and sensitivity. Torpid and lethargic children sleep still and quiet, but intelligent as well as spirited children mostly show greater activity. Even active idiots do not lose their activity in sleep. In the sleep actogram a method will be seen for distinguishing shy, backward children from imbeciles.

Any mental work in the evening, also exciting play and the telling of tales, lead to greater activity in the first hours of sleep.

Light and heat show no measurable effect.

Sleep-producing drugs in therapeutic doses do not lead to a change in the actogram. Where an overdose is given, it seems

[3] This conclusion which Karger offers is not based upon a careful quantitative analysis of his objective hypnograph records, but upon his own *Beobachtungen.* Karger, it should be noted, made his observations on *hospital* children. If this means he observed *sick* children, then reference to our studies on the effects of impending illness on the motility curves (pp. 85—94) will show at once why he was led to this assertion, which is not true of our "normal" sleep curves.

[4] We find little or no support in our records for this statement. After a child arises, walks 100 feet to a toilet and back to bed, sleep is often resumed in one minute or less.

to be a case of narcosis, whereby all reactivity is suspended. Retained activity is regarded as a sign of sleep in contrast to narcosis. However, bromides in the customary dosage reduce activity, among other things. In the case of luminal a delayed narcotic effect occurs the next night. Atropin and caffein produce an extremely great restlessness during the first hours of the night. Fever produces generally a very quiet sleep, even if produced artifically. The perception of pain is apparently retained during sleep. Complete withholding of nourishment effects a decrease in activity; plentiful nourishment effects an increase.

It is impossible within the limits of this monograph to present a complete historical summary of previous work and writings upon the general problem of sleep. Piéron (7) has already accomplished this task with a high degree of excellence for all work previous to 1913. Claparède (1) and Kleitman (6) have published reviews of the literature which bring up to date the summary of the contributions. Johnson and Weigand (4), Johnson, Swan, and Weigand (3), and Johnson and Swan (2) have reviewed the current literature on the problem, particularly with reference to underlying principles of measurement.

For the reader who is interested in the theoretical foundations of sleep, particularly in childhood, we shall present a bibliography of the principal studies which are extant at the present time. The situation in 1932 seems to be that there is a wide variety of theories based on almost every conceivable set of physiological and psychological hypotheses. Kleitman (6) has summarized these and rests the case with an attempt to lay down a set of criteria which the true theory must meet. These principles, six in number, are derived from the writings of Heubel, Mauthner, Hughlings-Jackson, Sidis, Coriat, Piéron, Dunlap, Haberman, and others. In outline they are as follows:

1. Sleep is an easily reversible inactivity of the highest functional centers of the cerebral cortex.

2. The inactivity is due to a functional break between the cerebral cortex and the other parts of the nervous system.

3. The functional break results from a marked decrease in the number of afferent impulses from the sensorium, especially proprioceptive impulses, which depend upon the degree of muscular tonus maintained.

4. Sleep is due to fatigue of the neuromuscular mechanism concerned in the maintenance of muscular tonus.

5. In the absence of such fatigue, sleep may result from complete muscular relaxation, intentional or unintentional.

6. Diurnal alternation of wakefulness and sleep is a "conditioned" phenomenon.

The evidence in justification of the above statements may be questioned by some, but one thing is clear: the habit aspect puts the problem definitely within the field of experimental psychology. One aspect of the sleep problem, recognized as of equal importance to any other, is the fact that the characteristic pattern of sleep is habitual. The evidence substantiating this statement will be presented in subsequent chapters of this monograph.

Several studies reported by Kleitman (6) indicate that an essential condition for "going to sleep" is a relaxation of the skeletal musculature and the effectual disappearance of many so-called distance-receptor reflexes. So, following the general plan of Szymanski and others, an appropriate method for the registration of postural movements in bed should yield records from which both amount of motility and the length of the quiet periods intervening could be determined.

Michelson (124), Canestrini (146), Karger (160), Trömner (166), and Swan (127) all criticize the attempts to measure the depth of sleep [Kohlschütter (123, 123a), Mönninghoff and Piesbergen (125)], claiming among other

things that the curves obtained "give no type of normal sleep" but show the characteristic form "under the safeguard of experimental conditions."[5]

Koffka (240) reports that Soltmann (253) stimulated the muscles and motor nerves of newborn and adult mammals (dogs and rabbits) by induction shocks and found characteristic differences between the reactions of young and mature animals. In the newborn: (1) the irritability was much less —in general, a much stronger current being needed to produce a muscular response; (2) the form of the muscular contraction was different—in the young the contraction and release were slow instead of being sharp and sudden; (3) the onset of fatigue was found to be very rapid; and (4) the muscles of the young were more highly susceptible to tetanus. For the adult animals the tetanus points ranged from seventy to eighty stimulations per second, but in the newborn it was as low as sixteen to eighteen. From the fact of (3), *i.e.*, greater fatiguability, is inferred the greater need for sleep in childhood and infancy, and from (1) the capacity to regain sleep so rapidly.

One of the most important contributions to our understanding of the process of relaxing, always a primary factor in going to sleep, is that of Jacobson (106). This volume represents observations and experiments conducted over a period of about a dozen years by a competent physician and physiologist, who has approached the problem not only from the standpoint of the therapeutic value of relaxation, but also as to its significance as an important and fundamental aspect of human behavior that is not restricted to the medical interest. The following quotations from

[5] In order to avoid the distortion of the curves due to the anxiety or "set" of the subject, we decided to use a larger number of nights on each individual so as to permit the subject to become thoroughly "at home" in the experimental bed, and to exercise particular care in selecting our child subjects. We return to this point more fully in a subsequent chapter.

Jacobson's book are self-explanatory. They are presented here as evidence supporting the use of increased motility as an index of nervous and muscular hypertension.

> Rest. . . . (1) repairs fatigue or exhaustion, thereby increasing the general resistance of the organism to infection and other noxious agents; (2) decreases the strain on the heart and blood vessels; (3) diminishes the energy output and thus also the required caloric intake; (4) quiets the nervous system, thus tending to relieve excitement, heightened reflexes, and often spastic states; and (5) diminishes the motion of the affected part or parts, thereby averting possible strain or injury. (p. 2)
>
> E. F. Mueller (1926) showed that the autonomic nervous system can excite leucocytosis, and describes two instances of insulin shock with increases to 19,000 and 28,000 in the brief time of fifteen minutes. (p. 19)
>
> Restlessness and insomnia [in endocarditis and pericarditis] may appear as disturbing factors and perhaps even turn the course of the disease by interfering with recuperation. (p. 23)
>
> [In heart disease] nervous overactivity during the day may persist at night in the form of restless and broken sleep, which fails to bring adequate refreshment. (p. 24)
>
> I have seen in one case (Klauder cites others, 1925) a sharply demarcated erythema on the neck and groin; in another a diffuse erythema with utricarial-like plaques limited to the neck appear, disappear, and reappear concurrently with symptoms of nervous hypertension. (p. 24)
>
> It has been my experience that wherever there is psychic disturbance, trained observation will reveal corresponding signs of neuromuscular hyperactivity or hypoactivity. (p. 25)
>
> As relaxation advances past the stage of residual tension . . . subjects report that this resulting condition is pleasant and restful. If persistent, it becomes the most restful form of natural sleep. . . . No university subject and no patient has ever considered it a suggested or hypnoidal or trance state or anything but a perfectly natural condition. It is only the person who has read a description without witnessing the actual procedure who might question this point. (p. 30)
>
> According to the present clinical and experimental experiences

up to date, if the patient is shown how to relax the voluntary system, there later tends to follow a similar quiescence of the vegetative apparatus. Emotions tend to subside as he relaxes. (p. 32)

In chronic cases relaxation becomes a gradual process—a matter of habit formation that may require months. (p. 32)

Relaxation tended to induce sleep. (p. 122)

The knee-jerk decreases parallel with advance relaxation. . . . There is usually a hang-over of the effects of extreme relaxation, since the jerk tends to remain diminished after the subject is instructed to cease relaxing, and only reinforcement or moving the leg brings the response back to normal. (p. 133)

All the subjects and patients who attained high skill in progressive relaxation spontaneously arrived at, and agreed in, their conclusions regarding psychological activities. With visual imagery there is a sense as from tenseness in the muscles of the ocular region. Without such faint tenseness, the image fails to appear. With complete ocular relaxation, the image disappears. This may be done by individuals of greatest skill and experience, not alone lying down, but also sitting up with the eyes open. . . . Motor or kinaesthetic imagery likewise may be relaxed away. (pp. 187–188)

Auditory imagery also is attended by a sense of tenseness, sometimes perhaps felt in the auditory apparatus, but characteristically in the ocular muscles. The individual tends to look toward the imaged source of sound. With the relaxation of such looking or other tension, the auditory image is absent.

Progressive relaxation is not, as a rule, perfect or complete save perhaps for brief periods of time. It is during such brief periods that imagery seems altogether absent. . . . It appears that natural sleep ensues after the imageless state is maintained for a relatively prolonged time.

With progressive muscular relaxation—not alone imagery, but also attention—recollection, thought-processes, and emotion gradually diminish.

An emotional state fails to exist in the presence of complete relaxation of the peripheral parts involved. (p. 218)

Hypnotic suggestion is difficult to develop in neurasthenia, according to Mobius, and in children, according to Bostroem. In our experience relaxation readily applies to both. (p. 304)

Washburn (59) has published in *Movement and Mental Imagery* an important theoretical discussion of the rôle of motor processes, while Rexroad (47), also, studied experimentally the influence of tensions in the extrinsic eye muscles on the visual image under certain conditions. We quote the following summary of his work, as contributing additional evidence to that obtained by Jacobson.

> After a small, faintly illumined square beside a brightly illumined one has been fixated for a time, the eyes will, when the stimulus lights are turned off, turn in the direction of the brightly illumined square. An image will be reported as present and drifting in the direction of the eye-movements. When the eyes make some other movement incompatible with that imposed by stimulation, no image is reported. The eyes will make such a movement after they have turned a certain distance, and also when the individual is directed to follow a knot moving in the direction opposite to the direction of stimulus-imposed movement, or is requested to fixate a point in the opposite direction. These findings lead to the conclusion either (a) that the visual image and recti tensions are correlated, or (b) that the visual image is in a large part recti tensions. The author favors the latter conclusion. (p. 433)

What does the work of Jacobson on progressive relaxation contribute to the possible interpretations that may be placed upon changes in sleep pattern—*e.g.*, produced by movies, drugs, season, age, deprivation below the optimal ration, etc.?

One important question receives immediate and decisive answer. Muscular hypertension in however small an amount is detrimental to the best, most recuperative sleep. If persistent or long continued, it may lead to structural as well as functional changes in the tissues. In degrees so small as to fail to show, by any existing method of registering, postural movement in sleep, muscular hypertension and

its nervous correlates may furnish the means of keeping the stream of imagery going on. This may be in the form of dreams, implicit speech, or mimetic imagery. This state is incompatible with rest. If we would secure for ourselves and our children, therefore, the maximum of health and happiness, we should give serious consideration to the hygiene of sleep habits.

The limiting case of hypotension, or relaxation, would be a complete cessation of all bodily functions—*i.e.*, death. The limiting case, similarly, of hypertension would be the extreme tonic contraction, seen in exophthalmic goiter, eclampsia, etc., which leads to coma and death. Normal living represents a band or distance intermediate to these extremes. The limits of the normal range are at present unknown. It is, however, possible to regard *every* departure from the null point which is neither hyper- nor hypotense as a movement in a direction which is, in the extreme, biologically destructive, yet which within limits is the ground upon which the processes we call life go on. The problem of the definition of these limits is a problem for future research.

Another fact is clearly brought out in considering the studies cited previously in this chapter. No statistical answer in terms of the standard deviation or other such measure could possibly give answer to the question as to how much motility, hypernormal or hyponormal, is bad for or good for a child. It so happens that this is one of those cases in which the statistics of variables does not wholly apply. In fact many misleading constructions can be placed upon the figures we shall present, if one is not ever mindful of the fallacies and the artificialities which may grow out of the logic of this form of mathematics. The mean or average is always a hypothetical, purely fictitious, composite image of an individual or case which can rarely if

ever be found in the actual sampling from which this figure is derived. However, it is necessary to present *some* figures to indicate the *trends*, or rough generalizations that may be drawn with safety from a study of a representative sampling of individuals. This we shall attempt to do. We shall also attempt to indicate those portions of the data which in our best judgment are suitable for statistical summarization, in distinction to those which we hold to be interpretable only in terms of experienced judgment. The real question becomes then a matter of the analysis of individual cases. A simple illustration will clarify this point. If two grains of a drug will produce a physiological effect in individual *A* equivalent to that effect produced in *B* by a six-grain dose, it becomes evident at once that a four-grain dose (the average of the two) will not be even a remote approximation to the optimum for either *A* or *B*. For the reasons stated, we present not only figures representing the central tendencies, but as many individual cases as space will permit.

The process of going to sleep is a process involving progressive relaxation of the skeletal muscles. This process is undoubtedly a concomitant of what Kleitman (6) has called the functional break between the cortex and the rest of the central nervous system. If an impression has been made on a child, such as the viewing of a motion picture, during the two or three hours previous to retiring, we know that such an impression has an inertia-effect. It does not cease immediately upon the withdrawal of the stimulus. Sleep motility, therefore, should serve as one possible index of the intensity and duration of this after-effect. By examining the sleep records of individual children night after night, we should be able to determine the influence of such factors or agents and to ascertain whether the effects produced are of a transitory or of a lasting character. The studies reported here were

made in order to determine so far as we could the extent to which attendance at various types of motion pictures would have a good or a bad influence on the mental and physical health of growing children. In order to ascertain the nature, amounts, and extents of these influences it is necessary that we first inquire into the nature of normal sleep in childhood and the extent to which it varies with age, sex, season of the year, and under experimentally controlled conditions that vary from the normal routine of living.

6. SUMMARY

PREDORMAL impressions may persist and produce a continuation of high tonus in the muscles. Sound sleep comes only in relatively complete relaxation of certain large segments of the body, with disappearance of certain reflexes (Czerny, Karger), heightening of electrical resistance in the skin (Peiper, Jacobson),[6] and the cessation of imagery, among other things. With movements made in readjusting posture there is a lowering of the reflex thresholds, such as lid tightening to light (Lambranzi, Karger, Kussmaul), and muscular hypertension (Jacobson), the necessary condition for waking, conscious life, since imagery disappears when subjects are able to relax sufficiently. Relative motility, therefore, is a suitable indicator of the extent to which the nervous system and the muscles are free or not free from the demands of the waking environment, or of the persistence of impressions received in the waking state. Hence motility, rather than the duration and frequency of the quiet periods, is the best function for study in our problem.

Young infants begin, like many animals, as polyphasic and later become monophasic as they take on habits imposed

[6] Landis has shown that, contrary to Richter, and Farmer and Chambers, change in electrical resistance in the skin is not covariant with "depth" of sleep, although there is a notable change in the transition from the waking to the sleeping state.

by their elders. The pattern of sleep in childhood is therefore probably largely artificial or habitual, and it remains to discover the characteristics of the individual's status in this respect.

Previous studies contribute little in supplying the desired information as to the characteristics of children's sleep at different ages. The setting of our problem is therefore unique among the studies on children's sleep.

CHAPTER II

THE CHILDREN USED AS SUBJECTS IN THE EXPERIMENTS

After reaching the decision to use motility as a comparative measure of "sleep" in children, and after tentatively deciding upon the general type of apparatus to be used, the question arose: where can enough subjects be secured? Shall children in their own homes be used in the experiments?

Various possibilities were considered. The use of children in the accustomed home situation presents many desirable features, for here one would get a result taken from the true life situation, and throughout the work we desired to introduce as little artificiality into the experimental situation as possible. It was soon found that in homes of average social status the range of *irregularity* in habits of eating, play, time of retiring, sleeping with another child, etc., were so great as disadvantages that it was decided to seek a place where greater numbers of children resided and where the living schedules were more uniform. We believed that the disadvantages of such uniformity were a lesser source of error than the fluctuations introduced from late hours, eating before retiring, or other radical *aperiodic* changes in the routine sure to be met with in the home. Then too, only a small number could be studied, since the necessary apparatus would have to be duplicated in each house. Our problem was to secure records on as large a number of children as seemed consistent or feasible with good experimental control and at the same time to keep the cost within the limited funds at our disposal.

The use of children in a boarding school, convent school,

or orphanage would give the advantage of numbers, but also there are here some difficulties—such as the range of ages, roommates, etc. Finally, after a number of these had been considered, the resources of the Ohio State Bureau of Juvenile Research at Columbus were suggested as a possibility. An inspection showed the Bureau to be almost ideal for such experimentation. After consultation with the director, Dr. C. H. Calhoon, and the State Director of Welfare, Mr. H. H. Griswold, permission was secured to use the children resident there. It is a pleasure to acknowledge here again the fine spirit of coöperation and helpfulness we received during the two and one half years of our studies from the children and the staff members at the Bureau. Often they gave freely of their time, at no little inconvenience to themselves, and placed at our disposal the complete family, medical, and scholastic histories of each child, together with the findings of the staff secured in their psychological examinations of each child. Without this extremely pleasant and helpful relationship our work could not have gone forward so smoothly during the time of the experiments.

The Ohio Bureau of Juvenile Research is built on the cottage plan, there being a boys' section and a girls' section, containing the sleeping and recreational quarters. A commons type dining room serves all the 150 resident children. The buildings are united by heated corridors and are arranged in a U-shape. In another wing there is a modern, well-equipped twelve-bed hospital, a dental clinic, and a laboratory for medical work. An administration building houses the offices and the rooms of the psychological laboratory.

The Bureau is located on West Broad Street about six miles from the Ohio State University. One and a half blocks west on Broad Street is a good, typical neighborhood picture theater, so that for the motion-picture work we could

walk the children to the theater in five minutes or less and have them back at the Bureau and ready for bed within fifteen minutes after the film was seen. When other more distant theaters were used because of the showing of certain films at the time, the children were transported in taxicabs.

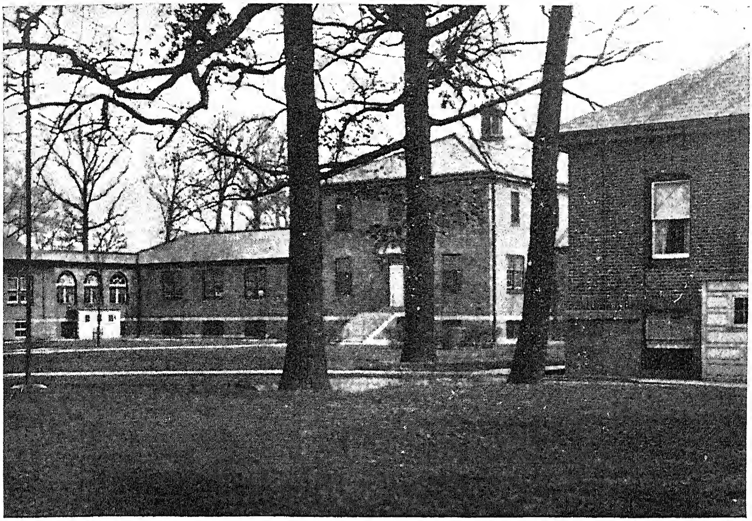
The Bureau is *not* a custodial institution, but was established for the observation and study of dependent and delinquent children, and children who present behavior problems of various sorts. Children are brought to the institution on reference from juvenile or probate courts; or are voluntarily brought in by parents seeking advice; legal guardians, private parties seeking to adopt a child, or by various child-caring agencies; or are referred for diagnosis by other divisions of the State Department of Public Welfare.

The period of observation is generally from six to eight weeks or longer, depending on the child. Between 500 and 600 children are admitted annually. These children range from about five to nineteen years of age.

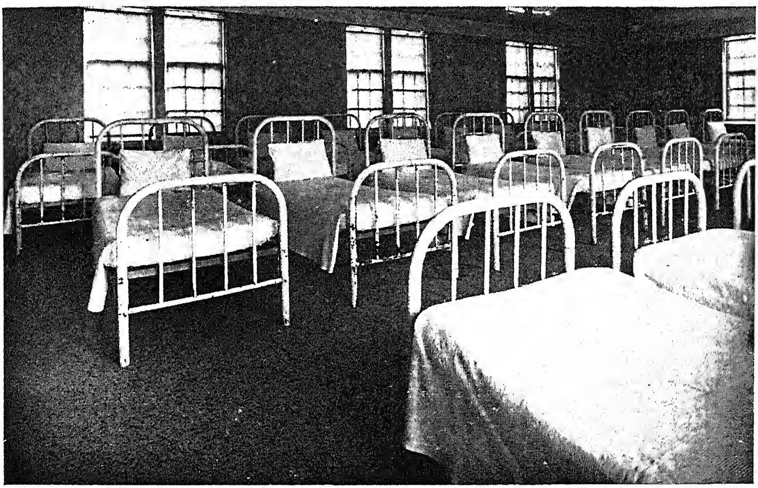
The daily routine at the Bureau has a precise regularity, which was most advantageous for the purposes of our investigations. This routine is as follows:

6:00 A.M.	Children arise
7:00	Breakfast
7:30–11:30	Minor duties and play
11:30–12:00	Quiet period
12:00–12:45	Lunch
12:45– 5:30	Play
5:30– 6:00	Quiet period
6:00– 6:45	Dinner
6:45– 8:00	Play
8:00 P.M.	Children retire [1]

[1] The twenty children taking part in our experiments at any one time were permitted an extra hour of free time for play, reading, listening to music, etc., between 8:00 and 9:00 P.M. On part of the nights their time was spent at the movies. Thus it was generally regarded as a privilege to be selected as an occupant of one of the experimental beds.



A View of the Ohio Bureau of Juvenile Research
Boys' Quarters on Right, Girls' on Left



The Boys' Dormitory
The Beds near the Wall Are the Ones Equipped with Hypnographs
Fig. 1

On Sundays the children arise at 7:00 and have breakfast at 8:00. Sunday-school services are held in the morning. Otherwise the routine is the same as on week days. The regularity of this routine is reflected in the stability of our normal sleep curves, as will be pointed out in greater detail in later sections.

The admission of a child to the Bureau involves the following routine: a quarantine period of several days, following a thorough medical and neurological examination by the two resident physicians; the completion of the histories on the child; a psychological examination, which consists of several half-hour sittings with one of the trained examiners on the staff who is delegated to study and test the child.

After this period of about two weeks the child is placed in the cottage dormitory with other children. Daily cottage reports on behavior are made by the attendants. The children have considerable time daily for group games and play outdoors, and during inclement weather they have the use of indoor recreation rooms supplied with reading matter, small games, phonographs and records, etc.

The food is served on a semi-cafeteria plan, the child being limited, of course, in his choice. All menus are planned by an expert dietician, and the food is clean, well cooked, and suited to growing children. Fresh milk from the State Hospital Farms adjoining is placed before each child at every meal, and he may have a second or third glass of milk if he so desires.

The children do some light work in the mornings, such as dusting, scrubbing, making beds, mowing the lawn, etc.

A school is maintained for those of the children who are kept for longer periods of observation and study. This school is taught by a woman who holds her Ph.D. degree in psychology.

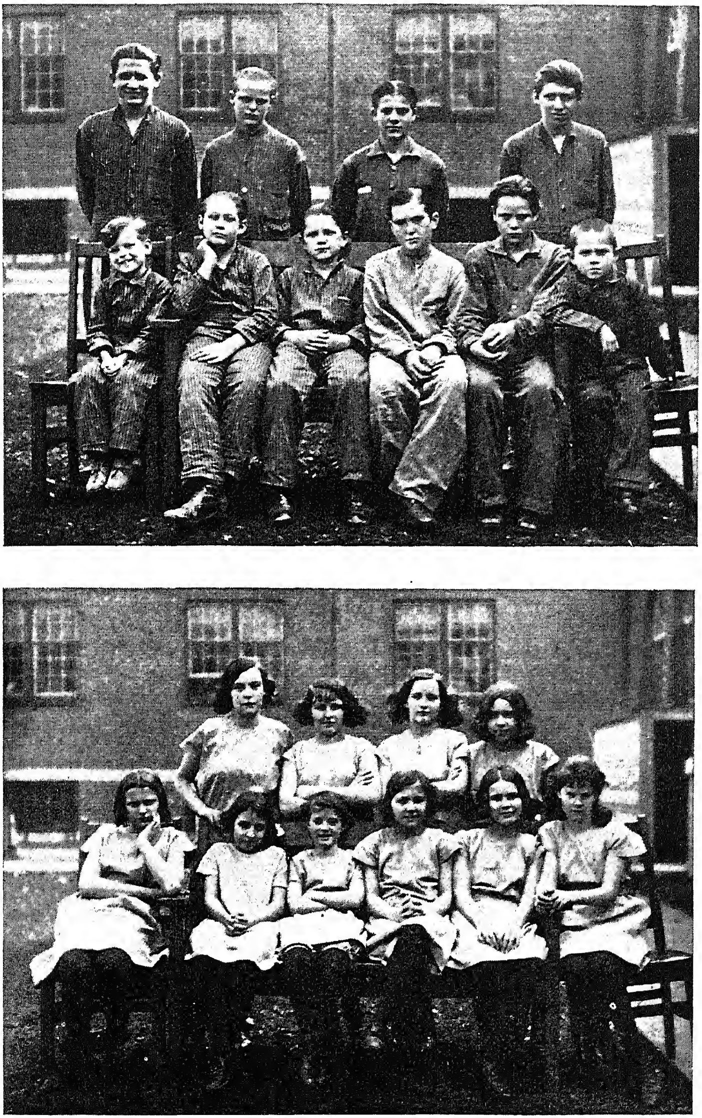
It is significant that the Bureau actually furnishes kind treatment, clean beds, good food,—in a word, more hygienic and probably happier conditions than most of these children have had in the homes from which they came.

The great majority of these children, from observation over a period of two years, are no less happy and contented, are under no greater tension than perhaps any sampling of similar size in an ordinary public elementary school population. Of course, any child who is intelligent *knows* that his presence in such a place has meaning. However, childhood and youth are sanguine, and the fears and emotional pressures of the first few days soon give way to the hopefulness and cheer in looking forward to the time of going home. Many would be glad to stay on. Others tell you they dislike it at the Bureau. This is only natural.

Most of these children have never had kind, loving, and solicitous parents. They have been "free" and self-sustaining almost all their lives. It is obvious, therefore, that they should dislike supervision or restraint.

The Bureau offers us a place where such factors as the daily activities, diet, health, time of retiring, etc., can be held uniform. It offers us the added advantage of enabling us to select children for each of our experimental groups who will represent different levels of age, brightness, temperament, etc. It offers us information about each child—family, social, medical, scholastic histories—which we should have great difficulty in obtaining were we to attempt to use children in their own homes.

The writers wish especially to emphasize the fact that their conclusions with reference to the normal motility curves are based upon experimentation with children who are in no way to be regarded as abnormal or not representative of children found in the average community. It may



A Typical Group of Boys and Girls Used in One of the Experiments

Fig 2

be well to anticipate and answer certain questions that might occur to the critical reader.

In the first place, we wish to remind the reader of one or two simple facts. When a child is admitted to the Bureau of Juvenile Research, let us say because of stealing, and he is classified as a juvenile delinquent, this fact does not immediately make the child over into a different biological organism. The respect in which he differs from most of the other children in his school grade consists mainly in the fact that from some constellation of "causes" this boy stole something *and was caught.* He may be brighter, cleverer, healthier than 75 per cent of all the other children of his age and grade. Now, does the fact that he has stolen something (possibly under conditions too strong for childish inhibitions, or possibly because of some Fagin-like training) make him an unfit subject to participate in an experiment on his digestion, his ability to kick a football, his memory for facts or principles, or the net impression made on him by the viewing of motion pictures? And again, do we not want to know something about these very children who have presented actual behavior problems? Most of these children are really neglected children—underprivileged children.

It might be urged that children confined to such an institution have a defective heredity. Our answer to this objection is that having available the individual case histories, we were careful in the selection of our subjects to include children representing a wide range of both hereditary and previous environmental conditions.

To those unfamiliar with institutional life in the Bureau it may seem that children in residence here for a period of observation may be subjected to an unusual emotional strain which would vitiate the experimental data so far

as their applicability to children living under normal home conditions is concerned. Those who are familiar with the lives of the children during their stay at the Bureau are agreed that after a short initial period of habituation, or acclimatization, they soon come to take the institutional *milieu* for granted and feel as much at ease as they would under home conditions. In fact some children, coming from homes in which the family life is more or less turbulent, live much more peaceful existences under the Bureau régime than in the home environments from which they came. At any rate, if emotional strain is a factor, it would not be entirely absent under home conditions and in many instances would be worse than that found in their experience here among the other children of about the same age and status. We may note parenthetically that very often the home conditions contribute largely in creating the problem child, so that under institutional conditions his behavior may better represent that of the normal child than if the experiment were conducted under home influences.

It should be pointed out further, that even were it granted that an emotional upset or an attitude or "set" unfavorable to the securing of true data might be present, this objection could not be raised to our study for three reasons: (1) The preliminary interview and quarantine period enabled us to select children who were regarded as suitable subjects by no less than *three* trained persons.[2] (2) No emotional stress can last for fifty consecutive days in a human being unless he is the victim of a readily recognizable psychosis. (3) The influence of motion pictures and other such agencies is not compared to a single night

[2] These were Dr. C. H. Calhoon and Mr. F. P. Bakes of the Bureau staff and one of the experimenters.

in which the second variable was *not* present, but to a norm, or standard. This norm or standard which represents the characteristic sleep pattern or habitus of any child was *experimentally* determined. The statistical technique used in doing this will be presented in the section dealing with the problem of normal sleep.

The best argument against the objection that institutional life tends to upset the child's normal behavior is the surprising stability and regularity of the normal sleep motility curves for children living under these conditions. The similarity of the normal motility curves of all children of the same age and sex, as we are able to show later, is also a forceful argument against the contention that these children differ markedly from the normal, for if this were the case, we should expect appreciable corresponding divergencies in the motility records, because some subjects would deviate from the normal considerably more than others. On the contrary, differences of such extreme degree are not found. A careful study of the figures to be presented later will clear up this point.

The children used in these experiments were not only thoroughly accustomed to the Bureau routine, but were also allowed sufficient time to become accustomed to the social situation of sleeping in the experimental beds in the same dormitory with the other children who constituted the experimental group, before the actual records were taken. This precaution will be made clearer in the description of the methods of the experiments in Chapter IV.

While the children under observation at the Bureau range from feeblemindedness to exceptional intelligence, over 25 per cent of them have I.Q.'s of 90 or above in the Stanford Revision of the Binet-Simon test, and over half of them have I.Q.'s above 80. In our selection of subjects,

except when we were particularly interested in studying the borderline and feebleminded cases, we have tried so far as possible to select subjects having I.Q.'s of 85 or better. While we were necessarily limited by the cases available, the periods of commitment, and various other factors, still it may be stated that on the whole our subjects did repre-

TABLE 1

AGE DISTRIBUTION OF BOYS IN EXPERIMENTS I TO IX

	Experiment									
Chron. Age	I	II	III	IV	V	VI	VII	VIII	IX	Total
5^6– 6^5			1							1
6^6– 7^5				1				1		2
7^6– 8^5		1	1		2	2	2	1		9
8^6– 9^5	1						1	1	1	4
9^6–10^5						2		1		3
10^6–11^5			1	3	1	1		1	1	8
11^6–12^5	1	3	1		1	1				7
12^6–13^5	2	1	2	2	3	3	1	2	2	18
13^6–14^5	1	2		1			1	1	1	7
14^6–15^5	2		2	1			2		1	8
15^6–16^5	2	1		1	2		2		1	9
16^6–17^5	3	2	1	1	1	1		1	1	11
17^6–18^5	1		1				1	1		4
18^6–19^5	1									1
Totals	14	10	10	10	10	10	10	10	8	92

TABLE 2

I.Q. DISTRIBUTION OF BOYS IN EXPERIMENTS I TO IX

	Experiment									
I.Q.	I	II	III	IV	V	VI	VII	VIII	IX	Total
40– 49		1								1
50– 59	2		1							3
60– 69	2			1						3
70– 79	2	4	2	4	1	1	2	1	1	18
80– 89	2		1	3	4	3	3	3	1	20
90– 99	1	3	6	2	4	4	2	3	2	27
100–109	3	1				2	2	2	4	14
110–119	2	1			1		1	1		6
Totals	14	10	10	10	10	10	10	10	8	92

sent a fair sampling of the general child population in the average community. Exact information with reference to the distribution of age and I.Q. in the experimental groups is given in Tables 1 to 4. Here it will be noted that 73.9 per cent of the subjects have I.Q.'s of 80 or better, while 22.8 per cent have I.Q.'s of 100 or better.

TABLE 3

AGE DISTRIBUTION OF GIRLS IN EXPERIMENTS II TO IX

	Experiment								
Chron. Age	II	III	IV	V	VI	VII	VIII	IX	Total
6^6– 7^5						1	1		2
7^6– 8^5		1	1	1	2		1	2	8
8^6– 9^5				1	1	1	2	2	7
9^6–10^5		1			2				3
10^6–11^5	1	1	1			1	1	1	6
11^6–12^5	1			1	1	1			4
12^6–13^5	2	2	2	1		1		1	9
13^6–14^5	2		2	1	1		1		7
14^6–15^5	1	3	1	2	1	2	3	2	15
15^6–16^5		1	2	2	1	1			7
16^6–17^5	2				1	1		2	6
17^6–18^5	1	1	1			1	1		5
Totals	10	10	10	9	10	10	10	10	79

TABLE 4

I.Q. DISTRIBUTION OF GIRLS IN EXPERIMENTS II TO IX

	Experiment								
I.Q.	II	III	IV	V	VI	VII	VIII	IX	Total
30– 39	1								1
40– 49									0
50– 59	1					1			2
60– 69	1			1	1	1			4
70– 79	3	1	3	1	4	1	2	1	16
80– 89		5	2	2	2	4	4	3	22
90– 99	4	1	2	1		2	3	2	15
100–109		3	2	3	3	1	1	4	17
110–119			1	1					2
Totals		10	10	9	10	10	10	10	79

A further consideration was the distribution of age groups. Here two alternatives were possible. The first would be to have all the children in each experiment of the same age and thus study a definite age level in each succeeding experiment. While this procedure would have the advantage of eliminating the age variable in each experimental group, it has the disadvantage of preventing the study of seasonal or other differences for all age groups and would necessitate that the experiments be continued over a number of years. The second alternative is to diversify the ages in each experimental group so that virtually the whole range from six to eighteen years is represented. This procedure had the practical advantage of permitting us to select children more nearly suited to serve as subjects, because it gave us a wider range of choice. The methodological advantage is that conditions would be uniform for the children of all ages represented in each group. Adopting this latter alternative, we selected our subjects so that each two-year age interval from five years six months to eighteen years five months would be represented by at least one or two subjects of both sexes. The final selection of the subjects was based upon personal interviews in which the experimenters attempted to gain such information as was not available in the case histories of the children. The actual distribution of I.Q.'s and ages for the nine experimental groups will be better understood by reference to the tables. Tables 1 and 2 give this distribution for the boys, Tables 3 and 4 give the same for the girls, while Tables 5 and 6 summarize these data for both sexes.

Only subjects who were in good health were used in the experiments. If illnesses requiring hospitalization appeared during an experiment, records of such subjects were not used in computing the norms or standards, but were used

for a special study, described in a later section. If the interruption was serious, another child was selected to take the place vacated, or if the experiment was far along in its course, the number of subjects was unavoidably reduced by one.

TABLE 5

AGE DISTRIBUTION OF CHILDREN IN ALL EXPERIMENTS IN NUMBER AND PER CENT

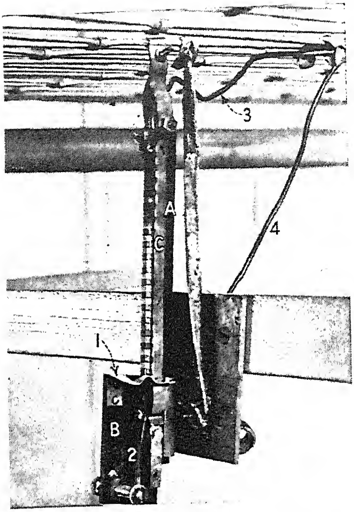
Chron. Age	Boys	Girls	Total	Per Cent	Cumulative Per Cent
5^6– 6^5	1	0	1	0.584	0.584
6^6– 7^5	2	2	4	2.339	2.923
7^6– 8^5	9	8	17	9.940	12.863
8^6– 9^5	4	7	11	6.432	19.295
9^6–10^5	3	3	6	3.509	22.804
10^6–11^5	8	6	14	8.187	30.991
11^6–12^5	7	4	11	6.432	37.423
12^6–13^5	18	9	27	15.789	53.212
13^6–14^5	7	7	14	8.187	61.399
14^6–15^5	8	15	23	13.450	74.849
15^6–16^5	9	7	16	9.356	84.205
16^6–17^5	11	6	17	9.940	94.145
17^6–18^5	4	5	9	5.263	99.408
18^6–19^5	1	0	1	0.584	99.992
Totals	92	79	171		

TABLE 6

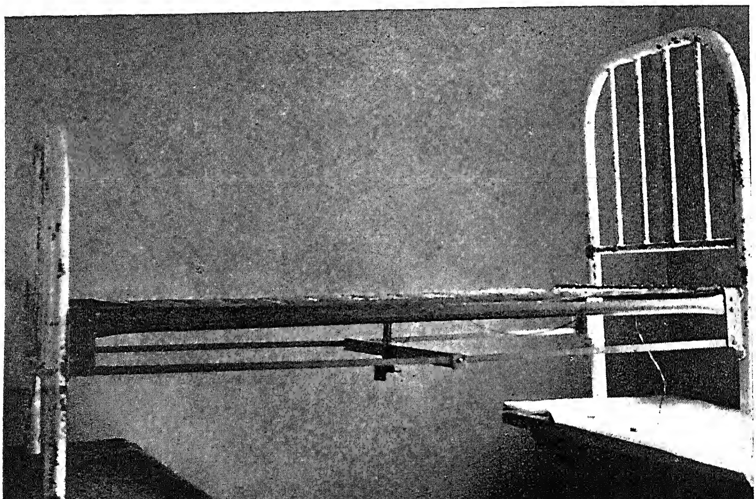
I.Q. DISTRIBUTION OF CHILDREN IN ALL EXPERIMENTS IN NUMBER AND PER CENT

I.Q.	Boys	Girls	Total	Per Cent	Cumulative Per Cent
30– 39	0	1	1	0.584	0.584
40– 49	1	0	1	0.584	1.168
50– 59	3	2	5	2.923	4.091
60– 69	3	4	7	4.093	8.184
70– 79	18	16	34	19.883	28.067
80– 89	20	22	42	24.561	52.628
90– 99	27	15	42	24.561	77.189
100–109	14	17	31	18.128	95.317
110–119	6	2	8	4.678	99.995
Totals	92	79	171		

Summarizing, we may say that because of the care used in selecting the subjects and because of the consistency of the results within the various age groups we feel justified in inferring that the experimental children represent a fair sampling of an average child population and that the regularity of the conditions of living at the Bureau favor rather than call into question the general applicability of the conclusions based upon our experimental results.



THE HYPNOGRAPH UNIT ATTACHED TO THE WOVEN WIRE BED-SPRING



A BED WITH HYPNOGRAPH MOUNTED IN CENTER OF SPRINGS FOR MAXIMAL SENSITIVITY TO POSTURAL MOVEMENTS

FIG. 3

CHAPTER III

APPARATUS

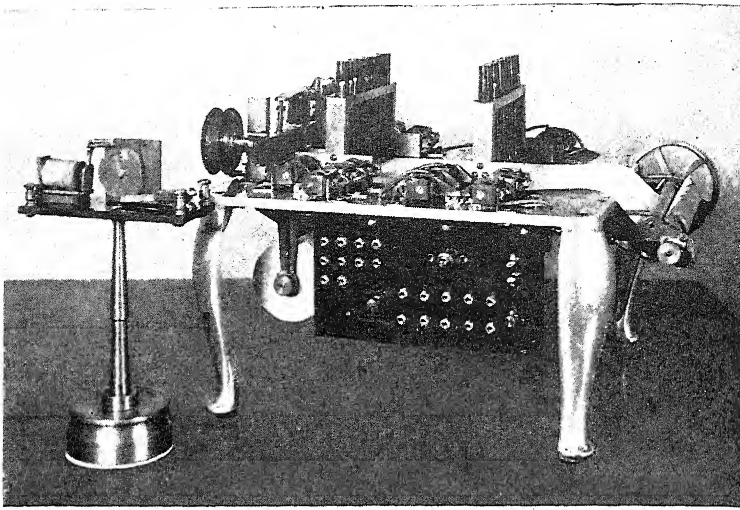
THE boys' dormitory in which the experimental beds are located is a room 45 feet by 24 feet with a 10-foot ceiling. The room is light and amply ventilated. There are sixteen windows. Ventilation is secured by a motor-driven fan system; fresh air heated by steam is completely changed every few minutes. There are thirty beds of the hospital type in this dormitory, arranged in three rows of ten beds each. The ten beds constituting the "test row" are shown in Fig. 1. The conditions and arrangement of the beds in the girls' dormitory are the same.

Each bed in the "test row" is equipped with a hypnograph unit of the type shown in Fig. 3. This unit comprises a movable bakelite shaft (A) and a stationary frame (B) provided with brush contacts. The movable shaft is $\frac{9}{16}$ inch by $\frac{3}{8}$ inch by 9 inches long. In one face of this shaft a series of brass inlays is set flush with the surface, providing a series of contacts 3 millimeters in width, separated by 3-millimeter intervals of insulation. The brass strip (C), Fig. 3, provides for a common lead for these contacts. The shaft is attached to the center of the bed-springs, which are of the woven wire suspension type. The stationary frame is a rectangular piece of bakelite on which are mounted two brush contacts of clock-spring steel. Brush (1), Fig. 3, makes contact with the common lead to the brass inlays, while brush (2), a brass shoe $2\frac{1}{2}$ millimeters wide, makes contact with the inlays. The two brushes are connected by a small 100-ohm resistance unit mounted on the opposite side of the bakelite (B).

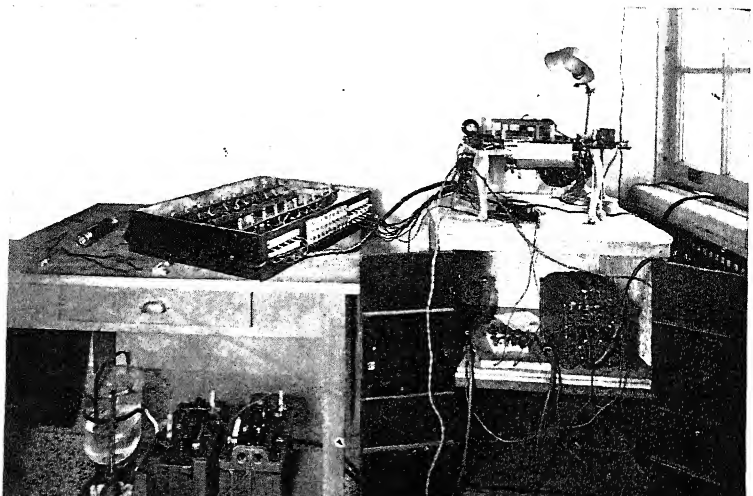
Wire (3) goes to the common lead to the brass inlays, while wire (4) is attached to brush (2). The stationary frame is mounted on a rectangular fiber support attached to a cross-member constructed of $\frac{3}{4}$ inch angle iron and connected to the rails midway between the head and foot of the bed. The cross-member acted both as a stabilizer for the side rails of the bed and as a mounting for the channel through which the movable bakelite rod of the hypnograph could slip with each change in posture of the sleeper. Thus the unit contains but one moving part.

The present design of this unit was determined by a series of preliminary trials. The first model was made in the shop of the psychological laboratories at the Ohio State University by the senior writer and his assistant, Dr. R. F. Wallace. It was mounted on one of the beds, placed in the writer's office, and was wired to a polygraph in an adjoining room. After several nights of trial sleeping, in which both of us served alternately as the sleeper, a model was finally constructed which gave the desired degree of sensitivity to movement. The balanced resistance device, which through suitable relays operates the small signal lamps before the operator and shows him immediately that the circuit through any bed is not functioning perfectly, was devised by Dr. Wallace.

Cables from both dormitories lead to a recording room in which are located the batteries, relay box, and polygraph recorder. Except for a common ground the circuit through each hypnograph is independent of the circuits through the others. In each circuit a hypnographic unit, a light relay, and an electromagnet are in series. The function of the hypnographic unit has already been discussed. The relay serves to detect broken circuits. As long as each circuit is closed, its relay will be energized; as soon as a circuit is



The Twenty-Pen Polygraph Designed and Built to Record Movements in Twenty Beds Simultaneously



The Arrangement of the Apparatus in the Recording Room Midway between the Boys' and Girls' Dormitories

Fig. 4

broken, the corresponding relay throws off, closing a light circuit and notifying the attendant of the trouble. A double-throw switch mounted on the relay box enables the operator to determine at once whether the failure to record is located in the bed, the line, or in the polygraph. The relay box, Fig. 4, contains twenty relays, one for each bed.

The polygraph unit,[1] Fig. 4, provides for the simultaneous registration of twenty records throughout the night. A paper tape 6 inches wide is driven at a constant speed by a special type G.E. synchronous motor. Twenty stylus pens, one for each bed, are mounted in two bridges, the front bridge holding the ten pens for the girls' beds and the rear bridge holding those for the boys' beds. Two colors of ink are used in the two bridges. Each pen is actuated by a light bar attached to the armature of a small electromagnet. Whenever brush (2) of the hypnograph (Fig. 3) passes over a brass contact in the movable shaft, the electromagnet in series is energized, causing the pen to make an offset in the base line of the corresponding record.

Timing gears driven by the synchronous motor are provided with contacts for closing the circuit once each minute through the electromagnet shown in Fig. 4. When this electromagnet is energized, a linotype bar attached to the armature of the magnet strikes a typewriter ribbon directly over the paper tape, printing a dotted line across the record, thus dividing the record into minutes.

The exact functioning of the hook-up may be more readily understood by reference to the wiring diagram, Fig. 5, of a single circuit. The hypnograph, the light relay, and the electromagnet are in series. Before the child occupies the bed, the hypnograph is in such a high position that both

[1] The construction of this unit, an improvement of the earlier 1925 model, was done by Mr. I. L. Hampton, mechanic in the shop of the psychological laboratory, Ohio State University.

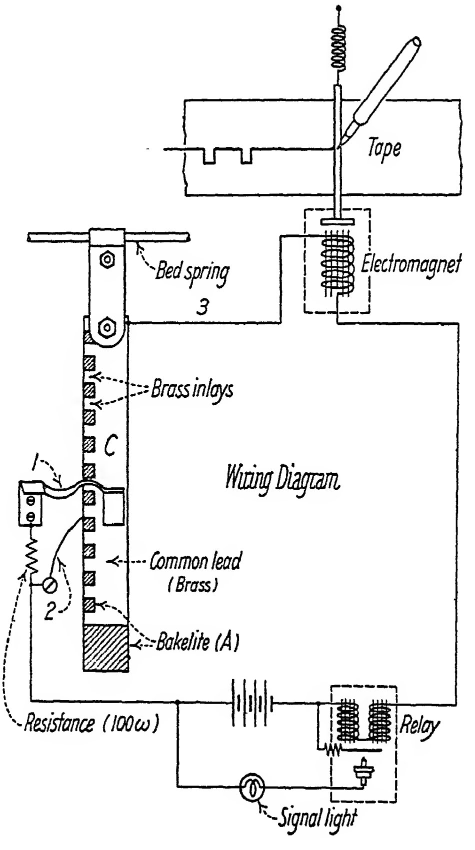

Tape
Electromagnet
Bed spring
3
Brass inlays
C
Wiring Diagram
1
Common lead
(Brass)
2
Bakelite (A)
Resistance (100ω)
Relay
Signal light

FIG. 5

brushes rest on the insulated portion labeled "bakelite" on the diagram. If the battery is connected, the relay being open, the signal light circuit will be closed. When the child goes to bed, brush (1) makes contact with the common lead, and the circuit is closed through the relay and electromagnet. This throws the relay armature, and the signal light goes out, notifying the experimenter that the child has gone to bed. It is obvious that if the child gets up during the night, the changes will occur in the reverse order, causing the signal light to flash on and will indicate to the experimenter that the child is out of bed. Or if the circuit is broken at any point, the relay will open, closing the signal light circuit. It will be noted that as long as brush (1) is in contact with the common lead, the circuit will be closed. If brush (2) is on an insulated area, all of the current must flow through the resistance unit, which permits enough current to flow through the circuit to close the relay, but not enough to throw the electromagnet on the polygraph. However, when brush (2) makes contact with a brass inlay, the resistance unit becomes one arm of a shunt, and enough current will flow directly through brush (2) to throw the electromagnet, which produces a shift in the line of the record.

Current was supplied by a 4-cell E.T.M. Exide unit. The line voltage was 7.5 volts, and the entire apparatus drew about 5 to 7 amperes of current when all children were in bed. A Tungar rectifier "floated" the battery in a continuous charge of 5 amperes during the night, and this charging rate was diminished to 1.5 amperes during the day.

Test circuits were provided to check the electromagnets and light circuits separately.

Two mechanical innovations in recording deserve special mention. The use of the double bridge permits the number of simultaneous records to be doubled without increasing the

width of the tape or size of the polygraph unit. Since the records indited by the pens in the front bridge are always exactly five minutes in advance of the records indited by those in the rear bridge, simultaneous comparison of all twenty records is possible by simple transposition. The use of the magnetically operated linotype bar effected a great economy, since it saved us the labor of ruling the record off into minutes by hand. The tape speed was $1\frac{1}{8}$ inch per minute.

The width of the brass inlays and of the intervals of insulation separating them are not arbitrary but were selected after trying out larger and smaller units. It was desirable that the mechanism should record such slight movements as the movement of the forearm when the elbow is bent; rotation of the head; and small postural readjustments; without being so extremely sensitive as to record respiratory movements and heart-beat. The present model seemed to be especially adapted to this purpose. Before any actual experiments were begun, preliminary trials were conducted in which the records of corresponding movements of young children and adults were compared. It was found that if the record was analyzed into active and quiet minutes, so that each minute in which any activity occurs is regarded as equivalent to any other minute in which activity occurs, such analysis yielded practically identical data for any given postural change whether made by a 45-pound child or a 150-pound adult. This finding is important, since it definitely eliminates the factor of body weight as a variable to be considered in the interpretation of results. While it is true that a given movement of the adult will be recorded by more offsets in the record line than a similar movement of a child, yet the number of active minutes is the same in both cases.[2]

[2] The difference, however, will not be found as great as might be supposed. Each wire of the springs is anchored at each end of the bed to a separate helical spring. The relative amount of difference in the "give" incident to differences of

It is to be remembered that the hypnograph records in both directions, so that it is equally sensitive to postural changes increasing or decreasing the pressure on the bed-springs.

Such precautions as calibrating checks, daily and weekly overhauling, inspection, and oiling were included in the routine duties of the operator.

body weight of the sleeper is small, and, such as it is, relatively unimportant, since, regardless of weight, the *change* from the point of equilibrium of the hypnograph is the thing we are recording.

CHAPTER IV

METHODS USED IN THE EXPERIMENTS

1. Experimental Procedure

There are large numbers of questions about the way experiments like these should be conducted that can only be answered by trying out various possibilities under the actual conditions. An investigator is often forced to make his work do double duty; first, in determining the procedure that will give the truest result, and second, in accumulating sufficient data to give him an approach to a random sampling of the population being studied.

We set out with the objective of securing results on at least one hundred children, the sexes to be equally represented, the age range from six to eighteen years to be covered, each level of brightness from the dull and backward to the superior to be included, and comparable groups taken at different seasons of the year.

The general plan of using each experimental group as its own control was followed. After selecting ten boys and ten girls to meet the above specifications, we assigned each child to a bed which he kept throughout the experiment. A period of from three to five nights was given during which the children became accustomed to go to sleep naturally in the new environment. After we were satisfied on this point, we began taking records. Each experiment consisted of about fifty nights, which were divided into at least three distinct segments. First there was a normal period, usually of about fifteen consecutive nights. This

gave us a stable norm for each child and for the group. Following this the children were taken to the movies for a certain number of nights in the two hours immediately before retiring. This in turn was followed by a second series of normal or post-movie nights.

This general plan was changed from experiment to experiment in order to enable us to study the effect of diversifying the factor of the number and distribution of the movies seen. In two experiments the program had to be shifted because of a scarlet-fever quarantine, and we were unable to take the children to the theater. We utilized this time for collecting data on other variables which we desired to use in comparison with the effect of motion-picture impressions. Table 7 gives the calendar of the experiments.

In various experiments different groups of children saw from one to fifteen motion pictures on successive nights. Our general method was to repeat the observations on several successive groups, thus increasing the statistical reliability of the findings and at the same time accumulating data on the influence of different types of films, different age levels, and different comparative conditions, such as the season of the year, the influence of coffee drinking, and an experimental insomnia series. There are manifest advantages in this method as opposed to using a much larger group of children in a single experiment.

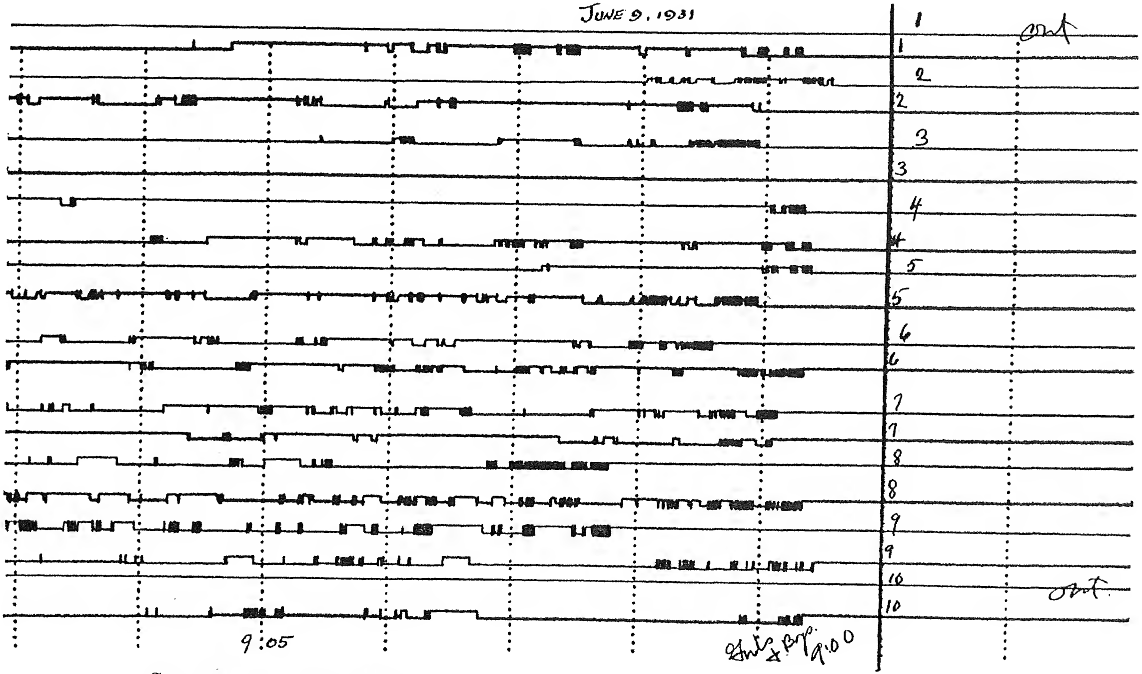
2. TREATMENT OF THE RECORDS

THE specially designed polygraph, illustrated on page 40, uses a paper tape 6 inches wide. On this tape there are to be found twenty lines, ten in red ink for the girls and ten in black for the boys. Each stir or movement records as one or more breaks in the continuous line for this subject, and the magnitude of the stir is approximately proportional

Table 7

STATISTICS OF THE EXPERIMENTS, MAY, 1929, TO MAY, 1931

Dates	Exp. No.	No. Nights						Subjects			Child-Nights
		Normal	Movie	Deprivation	Coffee	Holiday	Total	Boys	Girls	Total	
May 29–June 26, '29	I	24	5				29	10	0	10	290
July 13–Aug. 21, '29	II	25	15				40	10	10	20	800
Jan. 24–Mar. 14, '30	III	34	24				49	10	10	20	980
Mar. 22–Apr. 2, '30	IV	11	1				12	10	10	20	240
May 12–June 30, '30	V	45	5				50	10	10	20	1000
Oct. 5–Nov. 28, '30	VI	41	6	5			52	10	10	20	1040
Jan. 13–Mar. 3, '31	VII	37	3	9			49	10	10	20	980
Mar. 22–Apr. 30, '31	VIII	20			18		38	10	10	20	760
May 4–May 31, '31	IX	23			4	1	28	10	10	20	560
Totals		260	59	14	22	1	347	90	80	170	6650



SPECIMEN OF A TYPICAL RECORD, SHOWING A PORTION OF THE FIRST HOUR IN BED
(READ RIGHT TO LEFT.)
FIG. 6

to its duration. The record started when the child's weight first depressed the bed-spring. The record for each night comprised the 540 successive minutes for each child. What is the best way to score or tabulate these records?

After trying out several possibilities, some of them involving a prohibitive cost and amount of labor, we decided to use as our unit *one minute of time.* If movement or activity occurred in *any* portion of any minute, we counted that as an *active* minute. If a child was active in one minute and then did not stir for nine minutes, and became active again in each of the next three minutes, and so on throughout the night, we simply recorded in parallel columns on specially printed sheets the actual succession of the alternate periods of quiet and activity. Thus our summary sheets enabled us at any time to see by inspection exactly the pattern of distribution of these periods for any child from the time of retiring until he left the bed in the morning. The tape ran at a speed of about 1.1 inches a minute. So each night's record was indited upon a strip about forty-three feet long. All the children in our experiments retired at the same hour (9:00 P.M.) due in part to the institutional regulation and in part to our desire to keep this factor uniform. Hence we have arbitrarily assembled the data into larger units of one hour, corresponding to the clock hours of the night, for convenience. It should be noted that this is not an obligatory step, and that we may at our option plot our data *in any other conventional unit,* since the method of recording our original data in minutes *enables us always to go back to the undistorted minute* units of analysis taken numerically from the original records. As we shall be able to show later, the handling of the data in this fashion proved a very wise step. Had we used a larger unit, such for example as the 5-minute unit used in the Simmons studies by Johnson and

his associates on adult sleep, we should have introduced a considerable amount of distortion into the curves, since the distribution of the average length of the quiet periods shows that approximately half of all the quiet periods *are less than five minutes long*. In general the shorter the quiet period the more frequently it will be found to occur in any night's sleep of an "average" child. We do not wish to imply that the 5-minute unit is unsuited for studies on adult sleep. We simply wish to point out the desirability of keeping the unit of measurement as small as is possible in order to avoid any masking effects introduced into the results because of the arbitrary units employed.

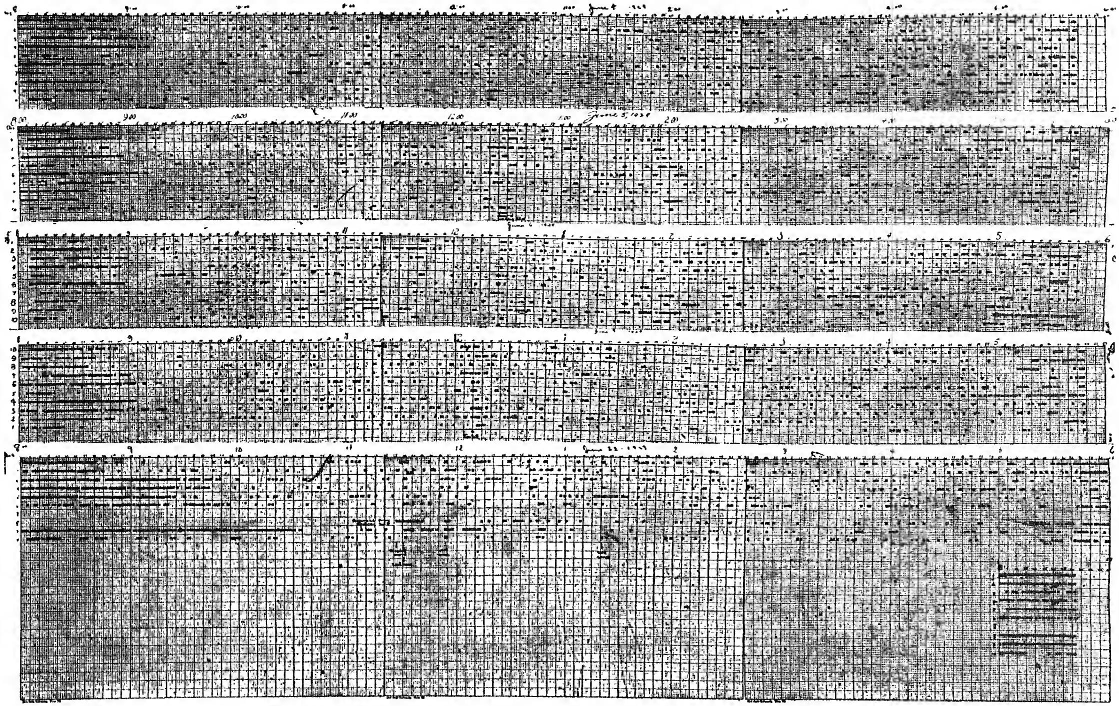
At the suggestion of Professors A. J. Carlson and N. Kleitman we have plotted the data of several children in quarter-hour intervals as well as in the clock hour divisions. These are shown in the next chapter (Fig. 24). On the basis of this comparison we can determine the relative influence on the shape of the curves of plotting to these divisions.

Dr. H. A. Edgerton has made a very complete and detailed analysis of the data of Experiment V, consisting of thirty-five normal, five movie, and ten post-movie normal nights. In doing this the minute-by-minute record of each child for each night was punched on 80-column Hollerith cards. These cards were then sorted and tabulated in a Hollerith sorting and printing-tabulating machine. By this means a number of important decisions can be reached about the significant measures to be used in presenting the data of all of the experiments. The findings from this analysis will be presented in Chapter VI. The method of treating our data also differs in one respect from the studies of Garvey, made on children aged two and one half to four years, and those of Johnson on adults (154). Both of these used

the average length of the quiet periods between the shifts in posture as the primary datum. The night was divided into a number of 5-minute units, and if any activity occurred in that period, it was regarded as "active." The end periods of activity bounding intervals of quiet were counted as half active.

Both on theoretical grounds (proposed in Chapter I) and on the greater differentiating value statistically, as shown in the analysis made by Dr. Edgerton, we have used both the length and distribution of the quiet periods and mean number of active minutes in each hour (or quarter-hour) of the total stay in bed. We have placed the main emphasis on the latter of these two measures. Our results will be shown generally in both units. It should be borne in mind that the one measure is not necessarily the reciprocal of the other. If there are 12 "active" minutes in any hour, it is impossible to say from this fact alone whether they are distributed uniformly throughout the hour, or if they are bunched so as to divide the interval into one, two, four, or more quiet periods. This means that we must derive the curves which we designate as representing the "active" minutes and those representing quiet periods separately from tabulations of the individual nightly records. If the reader will examine closely the graphic patterns of distribution of the periods of activity and quiet of Fig. 7, he will obtain at a glance a picture of the simultaneous original records of ten child sleepers on each of the five nights shown in the figure.

One further fact should be borne in mind by the reader. Children at home are more likely to vary in their sleeping and eating habits, as well as other activities, than the children under our controlled conditions. We should therefore naturally expect that under home conditions there would



Graphic Distribution of Minutes of Activity and Quiet for the Same Ten Boys on Five Different Nights

Fig. 7

be somewhat greater variation in the sleep patterns as a result of irregularity in the hour of retiring, etc. We have held to the view that the truer picture of sleep motility could be obtained where conditions were kept as constant as possible. Presumably this is about the condition which obtains in those homes where there is the maximum of concern about child health and hygiene.

CHAPTER V

NORMAL SLEEP MOTILITY

Bene dormit, qui non sentit quod male dormiat.—BACON.

1. INTRODUCTION

ONE approach to the problem of normal sleep is to begin with the assumption that *sleep* is an unknown which we cannot measure or describe directly. In previous sections we have shown that the alternate cycles of waking activity and sleeping are acquired during the early years of life, probably in much the same fashion that habits of walking, talking, etc., are put on. In early infancy[1] we note that while the child is said to "sleep" much of the time, yet he is in almost constant activity, mass activity involving the twitching of widespread muscle groups. As the child grows older a transition takes place. Now the period of sleep is a period of rest, or immobilization of the body, maintained for periods of shorter or longer duration. The high individuation of movements and the diversification of the activities engaged in during the waking hours demand that various of the body segments receive differential amounts of rest.

It is evident that we must determine in considerable detail the changes in the distribution of the alternate periods of rest and activity during the night so that we may know something of what is *normal* hourly nocturnal motility for

[1] Cf. Marquis, D. P., A Study of Activity and Postures in Infants' Sleep, *J. Genetic Psychol.*, 1933. The average number of active minutes per hour for night sleep in infants three to forty weeks of age was 24.4, with the average quiet period 4.9 minutes long. Infants therefore are much more active than older children. The infants' afternoon and morning naps were quieter than their night sleep, there being 10.5 active minutes per hour, with an average length of the quiet periods of 7.8 minutes.

any given child before we can attempt to determine the extent to which the pattern of distribution is influenced by the carry-over effects of seeing motion pictures or of other similar agencies. Even more significant than a norm, mean, or central tendency is the determination of the extent to which motility may be expected to vary when the conditions of life are kept as nearly constant and "normal," for each child, as it is possible to maintain them under the circumstances of our investigation. When we have this information we are in a position to determine the amount of deviation from these values that will represent a significant increase or decrease in the function under observation that is introduced concomitantly with the introduction of the experimental variable, such for example as the motion-picture experience before sleeping, the drinking of coffee, or what not.

Quite naturally we want to know the nature and extent of the changes in motility curves incidental to differences in age, sex, season of the year, daily activities other than those used as experimental variables, etc. But we wish to make it clear that we are primarily interested in determining the norm or average expectancy of motility for each child as an individual case. We shall, of course, present certain group averages. But we wish to emphasize again the necessity for some caution on the part of the reader in interpreting these *group* averages.

2. Establishment of a Stable Norm

There are a number of ways by which we can determine the norm for sleep motility. First, we may take a long series of normal nights, determine the mean number of active minutes per hour, and correlate these variables in the even-numbered nights with those in the odd-numbered nights. If the obtained value for the coefficient of correlation

exceeds a certain minimum, we may then be assured that the number of observations has been sufficient to give a truthful representation of the average which best represents the series.

Second, we may define normal sleep motility as the number of active minutes within any unit division of time, which is best represented by the arithmetic mean of a series of measures of the observed motility. This mean is derived from a number of observations sufficiently large that it represents a random sample of virtually an infinite number of such observations. In the practical case we may be content that we have secured a stable norm or average when the observed mean changes its value by less than about 2 per cent by the addition of one or more observations. The procedure in finding this value is as follows: We take a series of thirty-five normal nights' motility records on a child. We determine the cumulative averages of the mean active minutes per hour for the first, second, . . . n'th night. Whenever the cumulative average attains a satisfactory degree of stability (*e.g.*, varies less than about 1 or 2 per cent), we may be sure that we have sufficient observations to establish the norm.

Third, we may plot the curves representing the distribution of mean active minutes per hour and determine by inspection the range of variation of these curves for a series of single nights. This range can be expressed as a ribbon whose boundaries are defined as the limits of plus or minus one standard deviation unit from the mean. The first and second of these procedures have been used in treating the data of these experiments.

The description of the normal sleep motility pattern for any child involves therefore not only the statistical determination of a representative average or mean, but also the more difficult task of determining the contributory influ-

ence of such factors as temperature, environmental noises, presence of other sleepers in the room, diet, general state of health, activity during the day, season of the year, the age and sex of the child, etc.

Table 8 following gives the cumulative means for thirty-five normal nights of Experiment V. This table is read as

TABLE 8

ESTABLISHMENT OF A STABLE NORM

Mean Active Minutes per Hour for Periods of Five to Thirty-Five Nights[2]

Ten Boys		Cumulative Nights	Ten Girls	
5-Night * Means	Cumulative † Means		5-Night * Means	Cumulative † Means
7.24	7.24	5	9.36	9.36
7.45	7.34	10	8.99	9.17
7.29	7.32	15	8.69	9.013
7.71	7.42	20	9.02	9.015
8.24	7.58	25	9.18	9.05
8.10	7.67	30	8.91	9.025
8.27	7.75	35	8.89	9.01

* Means of successive five-night intervals.
† Means for number of nights indicated in column 3.

follows: The average for the first five nights for the boys was 7.24 mean active minutes per hour. For the first ten nights this value changes to 7.34, and for the first fifteen nights it becomes 7.32, etc. A study of this table reveals the fact that no significant change in the value of the average occurs after a period of from ten to fifteen nights. It should be further noted, however, that there is a slight increase in the average for the last ten nights as compared with the first ten. This change is incidental to the seasonal factor, as will be pointed out more fully in a later section.

As illustrative of the correlational method of determining the reliability of the norm, we present Table 9, taken from the results of Experiment III. This table represents the correlation of odd and even nights on both boys and

[2] Calculations based on data from Experiment V.

Table 9

INTERNAL RELIABILITY, EXPERIMENT III

Total and Average Active Minutes for Eleven Nights Normal Sleep for Boys and Girls on Odd and Even Nights; Correlation and Reliability Coefficients

Number of Boy or Girl	Boys				Girls			
	Odd Nights		Even Nights		Odd Nights		Even Nights	
	Total	Average	Total	Average	Total	Average	Total	Average
1	41.7	6.95	34.2	6.84				
2	33.5	5.59	24.9	4.98	40.7	8.14	32.6	6.53
3	34.6	6.92	27.2	6.8	43.4	7.23	28.5	4.75
4	58.1	11.62	51.9	10.38	17.2	5.73	19.3	6.43
5	58.2	9.7	39.2	7.84	36.1	7.22	32.9	6.58
6	45.4	7.57	33.6	6.72	29.6	5.92	29.8	5.96
7	39.0	9.75	41.5	10.38	37.1	6.18	32.3	5.38
8	32.4	6.48	31.4	6.28	32.1	8.03	30.8	7.70
9	23.8	7.93	18.2	6.07	29.7	5.94	27.1	5.43
10	18.5	3.09	14.3	2.86	32.1	6.43	27.8	5.56
Totals	385.2	75.60	316.4	69.15	298.0	69.82	261.1	54.32
Means	38.52	7.56	31.64	6.915	33.1	6.77	29.0	6.04

Correlation, odds-evens, $r = .944$
Reliability, $r = .973$

Correlation, odds-evens, $r = .883$
Reliability, $r = .927$

girls, based on the records of eleven successive nights of normal sleep. It will be noted that the coefficients of correlation are in general in the neighborhood of .9 and that the reliability coefficients (computed by the Spearman "prophecy" formula) run .97 for the boys and .93 for the girls.

Further evidence of the consistency to be found in the normal series can be obtained from an inspection of the standard deviations of the distributions and the means on the records of individual cases to be presented later in this chapter. The individual means are found to be on the average from twenty to thirty times the values of their own sigmas. This fact, taken together with the coefficient of reliability at .95 and the consistency of the cumulative average, is a bit of reinforcing evidence in support of our conclusion with respect to the stability of the norm or average.

Attention should be called to the fact that such environmental agencies as changes in temperature, environmental noises, and the other factors referred to previously were present during Experiments III and V, from which these tables were derived. In spite of this, we note that there is a high degree of consistency in the values representing the averages. Therefore we conclude that from ten to fifteen nights under the conditions specified in the previous description of our method are sufficient to yield a stable norm.

3. INFLUENCE OF TEMPERATURE AND RELATIVE HUMIDITY

THERE is a widespread popular belief that the motility of the sleeper varies directly with the temperature of the sleeping environment. To what extent is this belief supportable by fact? To what extent are variations in temperature and relative humidity within the sleeping room responsible for variations in the sleep motility curves of our children?

In order to ascertain the extent to which variations in motility are correlated with changes in temperature and relative humidity we made hourly determinations of these two variables over a period of several months. The ventilation within the dormitories was partly taken care of by a fan and air duct system and partly by the opening of the windows, so that during a series of experiments from June to the following February, for example, we were able to observe in the sleeping room a wide range of temperatures and relative humidities. Table 10 presents the relations between temperature and activity during normal

TABLE 10

RELATION BETWEEN TEMPERATURE AND ACTIVITY DURING NORMAL SLEEP

Mean Active Minutes per Hour

Temperature in Degrees Fahrenheit	Boys							Girls								Total
	7	8	9	10	11	12	13	6	7	8	9	10	11	12	13	
80							1								1	2
79																0
78			1	2	1							1	3			8
77			1	1	1	1					1	3				8
76			1								1					2
75				2	1					1	1		1			6
74			1									1				2
73			1	1	1				1		1		1			6
72			1	2						2		1				6
71		1							1							2
70		1							1							2
69			3	1						3	1					8
68	1								1							2
67		1	1	1						1		1		1		6
66		1	1						1		1					4
65	1	1	1						2			1				6
64			1									1				2
63	1		1					1					1			4
62																0
61																0
60				1					1							2
59	1									1						2
Totals	4	5	14	11	4	1	1	1	8	8	6	9	6	1	1	80

sleep for both boys and girls. An examination of this table shows a range of temperatures varying from 59° to 80° F. and a range of mean active minutes per hour from 6 to 13. The average temperature was 70.8°, and the average number of active minutes per hour was 9.2. The standard deviation of the active minutes was 1.489 and that of the temperatures was 5.466°. The coefficient of correlation of activity on temperature, $r_{xy} = .27$, where x is the active minutes and y the temperature. The two regression equations may be stated as follows:

$$y = .985(x - 9.17) + 70.8,$$
$$x = .073(y - 70.8) + 9.17.$$

In still another experiment (V), which extended from May 12 to June 15, we took observations over a range of temperatures from 50° to 78° F. as the mean hourly temperature of the night, and the mean active minutes per hour ranged from 6 to 14 inclusive. In this case, based on seventy observations, the coefficient of correlation of activity on temperature turned out to be $-.15$. The values of the standard deviations were $\sigma_x = 1.52$, and $\sigma_y = 8.175$. In still another case, involving an additional sample of fifty observations, where the temperatures ranged from 59° to 77° F., the correlation between mean active minutes per hour and temperature was .22. In this last case the average temperature was 68.9° F., and the average motility was 8.7 minutes per hour.

The time-worn phrase "It is not the temperature, but the humidity" led us to an examination of the possible influence of this factor. Records were kept over a period of fifty nights, in which the range of relative humidities varied from 60 to 82 per cent. During the time of these observations the mean number of active minutes per hour varied

from 6 to 12 inclusive. The coefficient of correlation of mean active minutes per hour on relative humidity was determined as $r = -.014$. The standard deviation of the distribution of mean active minutes in this case was 1.3, and that of the humidity readings was 5.83.

We can conclude from these figures, therefore, that there is practically no correspondence between changes in temperature or relative humidity and the mean number of active minutes per hour shown by any individual sleeper.

This statement should be somewhat qualified in the following respect: We have observed that under conditions where there is a sudden and exceptional change in temperature, 20° to 50° within a few hours, some temporary influence is noticeable. These cases are rare, however, and probably do not deserve serious consideration because of the temporary character of the relationship. Our figures, it will be noted, correspond almost identically with those obtained by Pratt (113), who secured a long series of measures on motility and temperature relations on newborn infants in the first fourteen days of life. Pratt found the correlations between temperature and motility to be never greater than $.205 \pm .024$ and between humidity and motility to be never greater than $.177 \pm .062$. It should be noted that our three correlations were obtained from data collected in the heat of the summer, during the wider fluctuating temperatures of autumn and spring, and in the cold of winter. Our data represent only the temperature of the air in the sleeping room. The temperature adjacent to the skin of the sleeper may have been quite different from that of the room. It may be that this skin temperature does correlate quite highly with motility. We have no information on the temperature adjacent to the skin. We may mention, however, the fact that all the children's beds are supplied with sheets,

either one or two heavy woolen blankets, and a bedspread. No other bedclothing is used either winter or summer. In view of the uniformity in the matter of bed covering, etc., it is unlikely that very great differences existed from individual to individual.

In order to be sure that the movie influences, to be presented later, were not due to temperature, we computed from the two regression equations of temperature on motility and motility on temperature the expectancy of motility change due to temperature on movie nights. The curves actually secured showed that the large increases and decreases after the movie were not associated with changes in temperature and humidity. Space forbids including the figures and curves here.

It has occurred to us that possibly the greatly reduced motility during the winter months might be accounted for by the immobilization produced by the weight of heavy bedding. Studies made on tonic immobility in animals have tended to show that a constant pressure applied to the body, tending to hold it in a slight restraint in a single posture, may conduce to a lowered average motility coefficient. We find nothing in our observations on these children to justify the belief that the small added weight of an additional blanket is sufficient to produce the large changes which we shall show are incidental to the comparative motility curves of winter and summer sleep.

4. OTHER POSSIBLE FACTORS INFLUENCING MOTILITY

KARGER has asserted (160) that changing the child sleeper from one room to another is not an important factor in his sleep motility and also that the presence of other children sleeping in the same room is not an important factor. The question arises, since there were thirty children in each of the

dormitories used in our experiments, to what extent a stir or movement of one child would influence other sleeping children separated by a space limited to two or three feet from the moving child. We have had many opportunities of observing at first hand the operation of this factor. Suppose, for instance, an extraneous noise such as the back-firing of a truck in the street, a sudden clap of thunder, or the like occurs. One child may stir. We can observe whether the two children sleeping in beds adjacent to him also stir. An examination of the records such as those illustrated in Fig. 7 will be illuminating on this point. If the reader will study this figure, he will note that the likelihood is not greater than chance that a stir in bed number 5 will be accompanied by a stir in either bed 4 or 6. It is true that the presence of several children in the same room may have considerable influence on the motility during the first half hour of the stay in bed, but beyond this we believe that this factor is of little or no consequence.

H. M. Johnson has studied this question much more carefully than any other investigator. He says (154) relative to the presence of other sleepers in the same room that "we can say with certainty that if two sleepers wish to rest and stir as they please, each of them being uninfluenced by the pose shifting of the other, they do not have to use separate bedrooms; separate beds will suffice."

The activities during the day have been previously described (Chapter II); likewise the diet of these children has been kept at a greater degree of uniformity than is usually found in the home life of children of these ages. While we do not deny the possibility of an occasional digestive upset, an occasional serious quarrel, or a day's play or other activity which may bring on excessive fatigue, we believe that these factors played but a slight rôle in

the determination of variability in the sleep motility curves. This is evidenced by the high consistency revealed by the figures cited in earlier sections of this chapter.

As will be observed from the examination of the individual curves presented in Figs. 20 and 26, there are wide differences among individuals of the same age and sex in the distribution of periods of greatest and least motility during the night. As Karger has pointed out, the factor generally understood by the term "temperament" is important. It is unquestionably true that some children are more restless sleepers than others. However, there is considerable evidence for believing that within the age range covered in our studies, the sleep of any individual is a fairly individual characteristic. This statement gains credence from the fact that the standard deviations computed on each hour of the night for one individual show less difference proportionately than do the mean values of the active minutes in any hour.

5. GENERAL CHARACTERISTICS OF THE NORMAL SLEEP MOTILITY CURVE

IN general, motility will be found to be greatest in the period immediately following the entry into bed. After a period varying from fifteen minutes to an hour and a half the motility gradually decreases until a minimum for the entire night is reached. The occurrence of this minimum early in the night seems to be highly consistent regardless of the slope of the curve preceding it. From this point there is a gradual and progressive hourly increase in general throughout the night until the time of awakening. In some individual cases there are marked peaks of motility, and these may occur roughly anywhere from the second hour to the ninth, and may number from one to three. The shape of the generalized

motility curve is approximately that of a U-shaped figure in which the left-hand member is considerably longer than the right-hand one. Table 11 following illustrates this point.

TABLE 11

RESULTS OF EXPERIMENT IV BY HOURS AND BY SUBJECTS

Mean Active Minutes per Hour, Normal Sleep; Sexes Separate

Hours of the Night	Boys	Girls	Subject No.	Boys	Girls
9	13.0	18.2	1	9.0	7.1
10	5.2	4.5	2	8.5	8.7
11	6.3	4.9	3	6.7	6.2
12	6.9	6.6	4	7.2	7.8
1	6.7	7.0	5	7.1	7.3
2	6.6	7.4	6	7.3	11.4
3	7.7	7.1	7	9.4	9.8
4	7.3	8.1	8	8.2	7.4
5	9.4	7.9	9	6.0	7.6
			10	7.8	9.6
Totals	69.1	71.7	Totals	77.2	82.9
Means	7.7	8.0	Means	7.7	8.3

The curve of the average length of the quiet periods shows a rather rapid lengthening out from the first hour to the second, attaining its maximum in the second hour of the night. From that point onward it drops gradually until the time of awakening. Fig. 11 is a composite illustrating these points, taken from all the data of all the experiments and combines the records of both boys and girls.

During the first hour in bed children will show activity during about 29.4 per cent of the total number of minutes, and this drops to a minimum of 8.5 per cent in the second hour. With the average child 14.5 per cent of the 540 minutes in bed are at least partly spent in activity. This is on the average 8.7 active minutes per hour. Thus about one and one third hours of the night are spent in moving about, rearranging posture, etc. Since this is the average, one half the children exceed this amount of

activity and one half do not attain it. For all children the average length of the quiet periods for the entire night is 10.8 minutes. From the second hour the quiet periods diminish progressively until the time of arising. The drop is from an average length of 16.9 minutes in the second hour to an average of 7.4 minutes in the ninth. One half of all the quiet periods are less than 5 minutes long; two thirds are less than 10 minutes long; three fourths are less than 15; and nine tenths are less than 30 minutes long. Only one quiet period in a hundred is as long as 60 minutes. Thus the common belief that children sleep quietly in one position for any considerable portion of the night is unfounded in fact. Table 12 following presents the frequency distributions of the quiet periods of various lengths.

TABLE 12

DISTRIBUTION OF QUIET PERIODS

Frequency in Number and Per Cent, Experiment III, Fifty Nights

Length in Min.	Pre-Movie				Movie			
	Boys		Girls		Boys		Girls	
	Cumulative		Cumulative		Cumulative		Cumulative	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
0–5	162.99	48.65	119.64	45.05	165.16	47.74	156.69	42.94
6–10	226.98	67.75	179.22	67.49	235.52	68.08	233.46	63.98
11–15	259.79	77.54	205.56	77.41	271.09	78.36	274.43	75.21
16–20	279.70	83.48	219.82	82.78	283.73	82.01	300.05	82.23
21–25	293.18	87.50	231.13	87.03	303.22	87.64	315.16	86.37
26–30	303.17	90.49	238.21	89.70	313.18	90.52	326.72	89.54
31–35	311.66	93.02	245.44	92.42	322.28	93.15	337.49	92.49
36–40	316.74	94.54	251.09	94.55	328.92	95.07	344.80	94.50
41–45	322.47	96.25	254.65	95.89	332.90	96.22	351.26	96.27
46–50	326.54	97.46	257.88	97.10	337.55	97.57	356.38	97.67
51–55	329.20	98.26	260.62	98.14	340.66	98.46	359.43	98.51
56–60	332.26	99.17	262.78	98.95	343.38	99.25	361.60	99.10
61–65	333.41	99.51	263.69	99.30	344.55	99.59	363.19	99.54
66–70	334.23	99.76	264.68	99.67	345.20	99.78	364.11	99.79
71–75	334.72	99.90	264.84	99.74	345.78	99.97	364.69	99.95
76–80	335.04	99.99	265.56	99.99	345.97	99.99	364.88	99.99

6. SEX AND AGE DIFFERENCES IN NORMAL SLEEP MOTILITY

THROUGHOUT the series of nine experiments reported in this monograph a large amount of data was amassed on normal sleep motility, since it was necessary to establish individual norms for each child with which to compare the motility records taken under the influence of the experimental variable. Although it has been shown above that ten to fifteen nights of normal sleep suffice for establishing a reliable norm, in most of our experiments records on more than ten successive nights of normal sleep were actually taken, while in one experiment data have been collected on thirty-five successive nights of normal sleep for twenty children. In Experiments II to IX we have obtained normal sleep data on seventy-eight boys and seventy-six girls for periods averaging over fifteen nights for each child, so that if sex and age differences in normal sleep motility exist, our results should be sufficient to bring them to light.[3]

Based on a comparison of his own findings on adults with those of Garvey on thirteen children two and one half to four years of age, on whom one hundred nights of records were taken, Johnson (154) states that "as a class, and on the whole, young children change from one position to another more often than adolescents." He further states that "Dr. Garvey has found that children tend much more closely than adults to conform their activity-patterns to one type. . . . Consequently he concluded that he could properly combine the records of all thirteen children in a single exhibit." While this generalization may hold for children from two and one half to four years of age, our own results show that the principle cannot be extended

[3] Experiment I is not considered, because no girls were used and because the children retired at 8:00 P.M. In Experiments II to IX inclusive the children retired at 9:00 P.M. and arose at 6:00 A.M. throughout the normal periods.

very far into the higher age levels. Indeed in the case of most children marked individual differences in the characteristic normal sleep motility curve develop at a very early age.

TABLE 13

SEX AND AGE DIFFERENCES

Mean Active Minutes per Hour, Averages of 2-Year Intervals

Age Group	N	Boys								
		Hours of the Night								
		9	10	11	12	1	2	3	4	5
5^6 – 7^6	3	13.0	3.9	5.2	6.7	5.3	6.0	5.6	6.2	9.8
7^7 – 9^6	13	12.9	3.7	4.2	4.8	5.1	4.9	5.4	5.5	11.1
9^7 –11^6	9	12.2	5.2	6.7	5.7	6.6	6.9	8.0	7.2	11.9
11^7 –13^6	23	19.2	5.6	6.9	7.9	7.4	7.9	8.1	8.3	13.5
13^7 –15^6	14	22.2	6.2	7.4	8.3	7.9	8.2	7.1	9.2	11.7
15^7 –17^6	13	20.8	6.7	7.2	8.1	8.1	7.9	8.7	8.5	12.8
17^7+	3	14.6	7.8	7.6	7.8	7.2	7.1	8.1	9.6	11.8
		Girls								
6^6 – 7^6	2	5.0	3.3	4.2	4.6	4.4	3.6	4.2	5.6	17.7
7^7 – 9^6	14	12.0	4.5	4.0	5.2	5.6	5.3	5.9	5.6	15.7
9^7 –11^6	11	14.6	5.0	5.5	6.8	6.5	6.4	6.6	6.8	11.8
11^7 –13^6	12	18.9	4.8	4.7	5.4	6.2	6.8	6.4	7.8	12.2
13^7 –15^6	19	17.0	5.5	5.7	7.1	7.9	7.5	7.8	7.7	15.0
15^7 –17^6	15	16.4	6.6	5.9	7.2	7.2	7.3	7.8	8.3	12.9
17^7+	3	13.1	3.8	4.6	6.4	7.4	5.8	4.9	5.8	17.9

TABLE 14

SEX AND AGE DIFFERENCES

Mean Active Minutes per Hour, 4- and 5-Year Intervals, Normal Sleep

Age Group	N	Boys								
		Hours of the Night								
		9	10	11	12	1	2	3	4	5
5^6 –10^6	19	12.9	3.9	4.6	5.1	5.5	5.4	5.8	5.8	11.1
10^7 –14^6	36	17.7	5.8	6.8	7.8	7.3	7.8	8.1	8.3	12.8
14^7 –18^0	23	17.6	6.6	7.3	8.0	7.9	7.8	8.4	8.9	12.5
		Girls								
6^6 –10^6	22	11.9	4.4	4.5	5.5	5.6	5.4	5.9	5.8	14.2
10^7 –14^6	22	22.9	5.3	5.0	6.2	6.8	6.9	6.8	7.9	13.2
14^7 –18^0	32	15.9	5.8	5.8	7.1	7.5	7.3	7.5	7.6	14.4

Tables 13 and 14, based on the records of 156 children, show that Garvey's generalization does not apply to children from six to eighteen years of age. From an examination of these tables we may observe the following relations.

1. Although wide differences are shown in the patterns of some of the individual normal sleep motility curves, Table 13 indicates that there is relatively little overlapping of the curves for different age groups; but nevertheless there is an unmistakable trend in the direction of *motility varying directly with age.* This latter relation is even more strikingly demonstrated by Table 14, in which averages are shown for the three age groups 5^6 to 10^6, 10^7 to 14^6, and 14^7 to 18, and by Fig. 8, which represents these data from 10:00 P.M. to 5:00 A.M.

2. An examination of Table 14 and Fig. 8 shows that there are practically no sex differences in the youngest age group, while the sex differences are very marked for the age group 10^7 to 14^6. The curve for the boys of this age is much higher than that for the girls between the hours of 10:00 and 5:00, even though the curve for the girls shows a considerable increase over that for the youngest age group. This same sex difference is preserved at the highest age level, but the differences are not so great. At this point we must call attention to the fact that these figures have not been corrected for seasonal differences. If this were done, the figures for the boys would show a considerable increase throughout, the highest age group being most affected; those for the girls would be decreased slightly for the lower age groups and increased for the higher. These corrections would *accentuate* the age differences among the various groups and the sex difference between the middle age groups. We may conclude, therefore, that no significant sex differences in the normal motility curve appear between the ages of 5^6 and 10^6, while a striking differentiation of the sexes occurs during the period of puberty and is maintained, though to a lesser degree, throughout adolescence.

3. The boys of the highest age group are 64 per cent more active from 10:00 to 11:00, their quietest hour, than are those of the lowest age group in the same hour. The oldest girls are

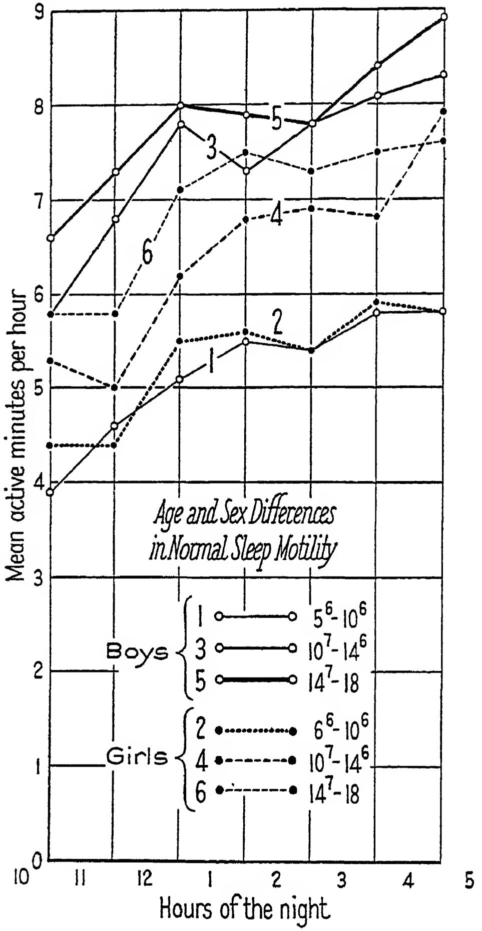
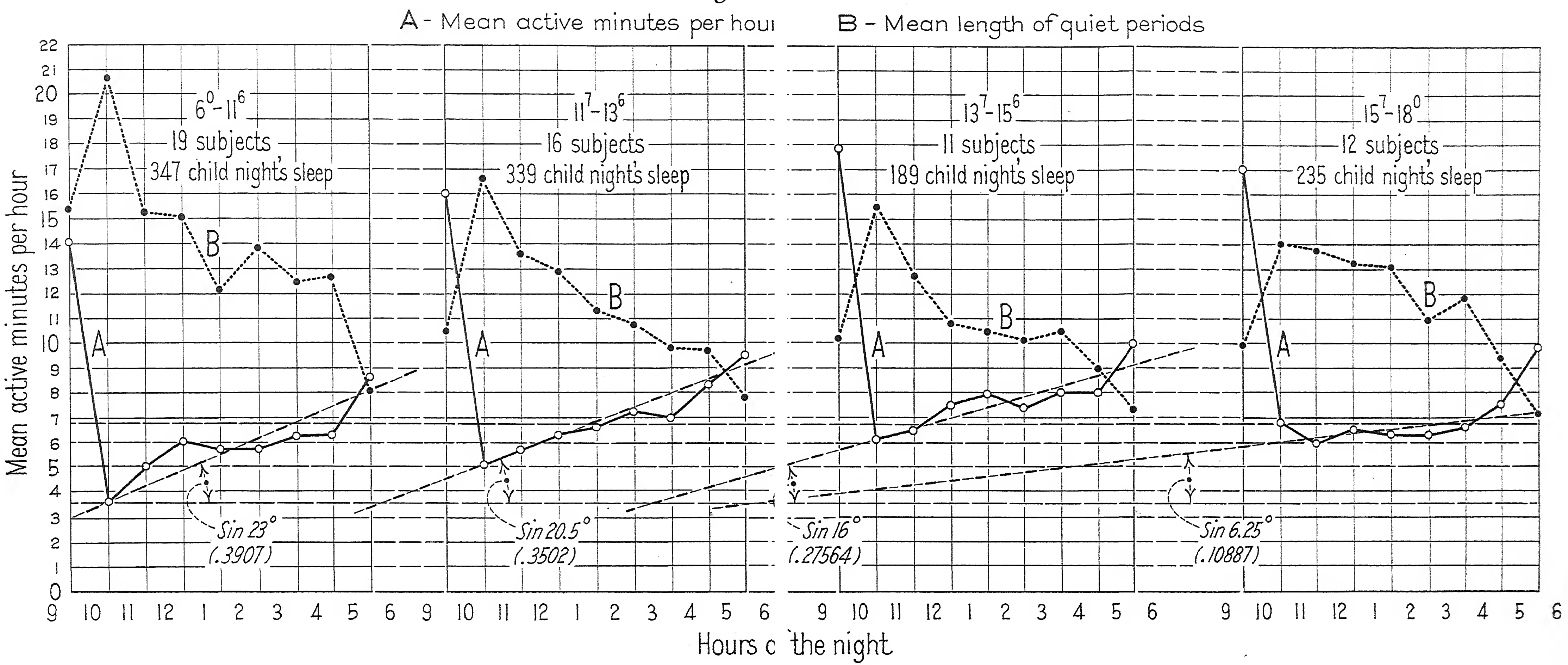

Age and Sex Differences
in Normal Sleep Motility
Mean active minutes per hour
Hours of the night
Boys
1 5⁶-10⁶
3 10⁷-14⁶
5 14⁷-18
Girls
2 6⁶-10⁶
4 10⁷-14⁶
6 14⁷-18

FIG. 8

Age L :fferences



F 3.9

32 per cent more active than the youngest during this hour. About the same differences are maintained throughout the night with the exception of the first and last hours.

4. In the age group 5^6 to 10^6 the boys are more active than the girls in two of the nine hours (9:00 to 11:00). In the age group 10^7 to 14^6 the boys are more active than the girls in seven of the nine hours (10:00 to 5:00), while in the highest age group the boys are more active than the girls in eight of the nine hours (9:00 to 5:00). The apparent increase for the girls in the last hour may be due to the fact that the girls were in the habit of arising a few minutes earlier than the boys.

5. The two sexes appear to show two rather distinct types of curves in the two higher age groups, the difference being easier to observe from the graphs than it is to describe. One point which stands out is that the quietest hour for all groups of the boys is the second, while the girls do not show their upward trend until after the third hour. These curves also show clearly the upward trend mentioned in Section 5 of this chapter.

Fig. 9, based on the analysis of the data of the earlier experiments, shows that the younger children (6 to 10) are not only less active but have 27 per cent longer quiet periods than the eleven- to fourteen-year group. This figure also shows that the changes in the mean lengths of the quiet periods in the four age groups parallel the changes in mean hourly activity. This latter relation could not have been predicted beforehand, since the mean length of the quiet periods depends upon the distribution of activity within each hour as well as upon the amount of activity. In Fig. 9 an abscissa has been passed through the point of minimal activity for each age group. Usually this point occurs in the second hour. From this minimum we pass a dotted line which is the approximate best fitting line through the points representing the succeeding hourly increments in motility. This dotted line represents the slope of the return

to the waking state and can be represented by a single figure which is the sine of the angle with the abscissa. An examination of the values of these angles for the succeeding age groups shows that there is practically a geometric decrement from group to group. One possible interpretation of this set of relations is that as the child grows older, from the sixth to the eighteenth year, his escape from the waking world in sleep becomes less and less perfect. We are unable to say whether this observed effect is directly and proportionately related to the intensity or amount of muscular activity during the day, or whether it is predominately due to neurological and psychological factors. In senescence it well known that the total amount of sleep required diminishes considerably from that required in middle age. Fig. 10 presents the curves for the three age groups superposed.

7. Seasonal Variations

That seasonal rhythms of human behavior seem to exist may be indicated by seasonal periodicity in growth, in height and weight, in blood pressure, in haemoglobin content of the blood, in basal metabolism, and in certain aspects of human conduct. Popularly, it is believed that there is a seasonal variation in sleep; that in winter one sleeps like the proverbial log and is unable to sleep a wink on hot summer nights. For a great number of people this variation is held to be due to abrupt temperature changes, and frequently differences due to season and temperature are confused.

Since the factors of temperature and relative humidity have been shown in Section 3 of this chapter to exert no significant influence, it is only necessary to determine whether or not any seasonal variations in motility which may appear in the various age and sex groups are statistically reliable.

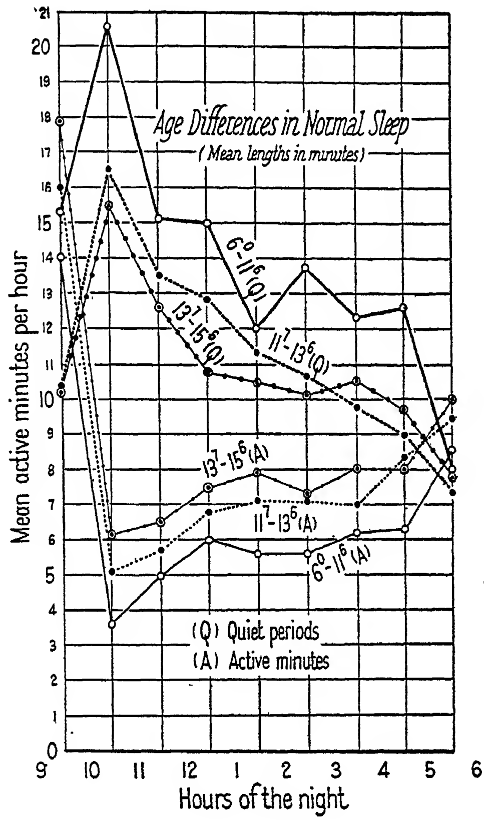

Age Differences in Normal Sleep
(Mean lengths in minutes)
Mean active minutes per hour
Hours of the night
(Q) Quiet periods
(A) Active minutes
6⁰-11⁶(Q)
13⁷-15⁶(Q)
11⁷-13⁶(Q)
13⁷-15⁶(A)
11⁷-13⁶(A)
6⁰-11⁶(A)

FIG. 10

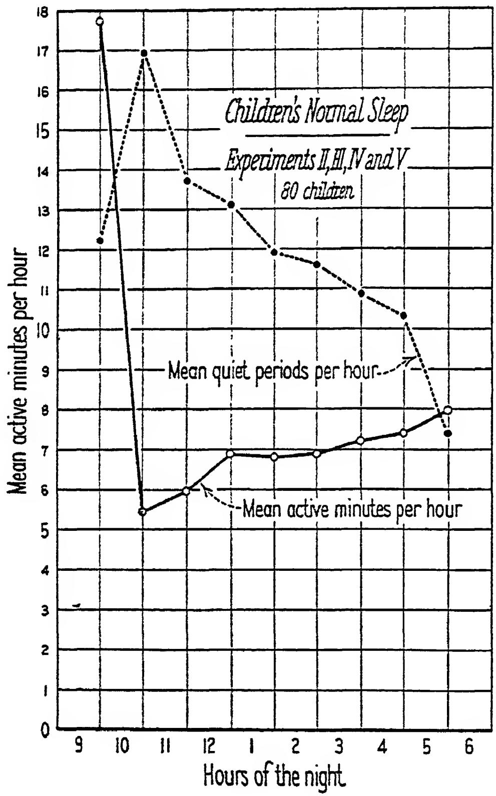

Children's Normal Sleep
Experiments II, III, IV and V
80 children
Mean quiet periods per hour
Mean active minutes per hour
Mean active minutes per hour
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
9
10
11
12
1
2
3
4
5
6
Hours of the night

FIG. 11

Kleitman (6) states that "the only extensive data on duration of sleep are contained in a statistical study of the sleep of 210 inmates of an insane asylum by Ladame, based on direct observation by attendants or nurses. An analysis of 57,000 nights' records showed that women sleep about 30 minutes less than men, but they sleep more soundly. In all patients there were seasonal variations in length of sleep. The curves show a maximum of sleep in April, a minimum in January and February, with a high submaximal plateau during the summer months. According to Haas sleep in men is lighter in summer than in winter, but Szymanski's canaries slept more soundly in the summer and early autumn than in winter."

With respect to seasonal variations in growth Malling-Hansen (132), Schmid-Monnard (135), Makower and Bleyer (130) found that minimal growth occurs between mid-April and mid-July, maximal growth between mid-July and mid-December. Porter and Baird (134) essentially corroborate these and show that children born in the season January to June, the season of slow growth, are lighter than children of exactly the same age born in the season of more rapid growth, July to December.

In physical strength of growing children Schuyten (136) found a falling period from January to March, a rising period from May to June, a falling period from July to September, and a rising period from September to December. Lehman and Pedersen (136) found, for a group of growing boys, a rising period from February to June, a stationary period from July to September, and a rise to December, with a stationary period from December to February. Peaks (136) essentially corroborates Lehman and Pedersen and finds three distinct periods: a period of growth from September to about the middle of December, a period of

depression from January to March, and a period of renewed growth from March to June.

Basal metabolism tends to be at a low level in the winter and to rise to a higher level during the spring and summer according to Benedict and Carpenter (128) and Benedict and Gustafson (129).

Dexter (131) studied the correlation of weather conditions with crime, insanity, school attendance and discipline, and clerical accuracy. His widely quoted work, which, however, is not highly significant from a psychological point of view, indicates that the colder months are periods of quiescence for the activities he studied, a maximum of activity being found in the hottest part of the year.

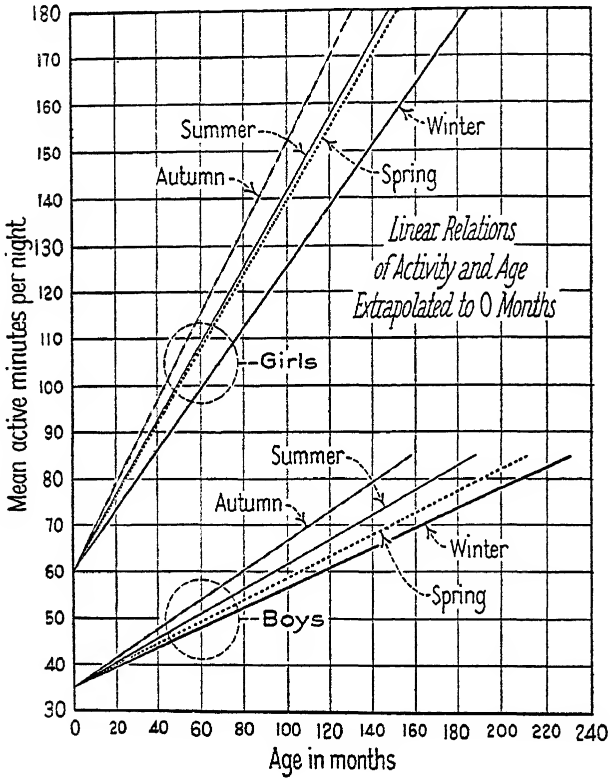
A low level of motility during sleep might be expected during the winter, as this is the season of slow growth, of minimum physical strength, of low level in basal metabolism, and of quiescence in the activities studied by Dexter. In the autumn growth is at a maximum, increase in physical strength is indicated, and basal metabolism is at a higher level,—all of which might indicate the greatest amount of sleep motility. In the spring and summer months a middle amount of motility might be expected, as is indicated by a middle period in these phases.

The present analysis of seasonal variations was carried out prior to the completion of the last two experiments and consequently is based on the data of Experiments II to VII inclusive. Experiment I was excluded for reasons mentioned previously. Experiment II represents 190 child-nights of normal sleep, III 204, IV 209, V 665, VI 320, and VII 300, a total of 1888 child-nights. Experiments III and IV combined give winter sleep, IV and V spring, II summer, and VI autumn.

The mean of the total activity per night is used as a basis for the comparisons made in this section.

The analysis of the data has already indicated that the relationship between age and activity is approximately of a linear type, and a preliminary study showed that the lower the age, the smaller was the amount of seasonal variation. A family of straight lines was chosen for the present data because of the greater simplicity of treatment and interpretation, because straight lines fit the experimental data fairly well, and because the number of cases at the lower and higher age levels are few, the majority being at the adolescent ages. With both the boys and girls in Experiments II to VII only 23 per cent of the cases are below eleven years. There are only 12 per cent of the girls and 10 per cent of the boys above sixteen years of age. The remainder of the cases fall in the period in which a rise in the growth curve also occurs, and this rise is best fitted by a straight line.

The relative differences between ages in total activity per night are about equal, and the data suggest that the lines representing these relations would converge toward the lower age levels and that they would intersect at a point near age 0, when sleep activity is perhaps independent of season. The method of least squares was used to fit straight lines to the data expressing the relationship between age and total activity for each season. The least squares equations were corrected for the assumptions that the relative variabilities between age and total activity per night are about equal and that the seasonal lines intersect at a point near age 0. Assuming that these lines actually intersect at age 0, each one must pass through the point where age is 0 and activity is the average of the constant terms in the equations obtained by least squares. These constants were found to be 37.5 for the boys and 52.8 for the girls. Each line must also pass through a point whose



Mean active minutes per night
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
0
20
40
60
80
100
120
140
160
180
200
220
240
Age in months
Summer
Autumn
Winter
Spring
Girls
Linear Relations of Activity and Age Extrapolated to 0 Months
Summer
Autumn
Winter
Spring
Boys

FIG. 12

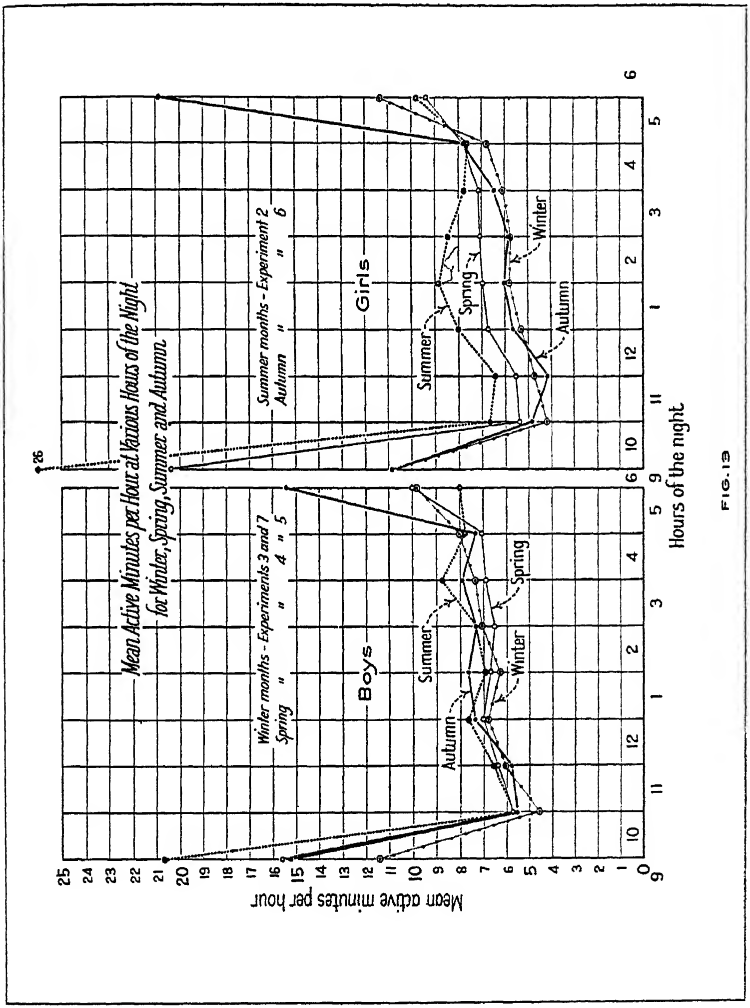

Mean Active Minutes per Hour at Various Hours of the Night
for Winter, Spring, Summer and Autumn
Winter months - Experiments 3 and 7
Spring " " 4 " 5
Summer months - Experiment 2
Autumn " " 6
Boys
Girls
Summer
Spring
Winter
Autumn
Mean active minutes per hour
Hours of the night

FIG. 13

coördinates are the average age and average activity score for the appropriate seasonal group. The equations derived thus, showing the relationship between age and activity, are as follows:

Boys	Winter	$y = .21x + 37.5$
	Spring	$y = .23x + 37.5$
	Summer	$y = .26x + 37.5$
	Autumn	$y = .31x + 37.5$
Girls	Winter	$y = .05x + 52.8$
	Spring	$y = .15x + 52.8$
	Summer	$y = .22x + 52.8$
	Autumn	$y = .14x + 52.8$

where y is the mean total activity and x is the age in months. These curves are shown in Figs. 12 and 13.

When the scores are corrected to the winter curve as a base, the sigmas are found to be somewhat reduced, thus indicating the fitness of these measures. When correction is made for both season and age, the sigmas are still further reduced. When the scores corrected for age and season are correlated with the uncorrected scores, the correlations are: for the boys, $r = -.055 \pm .09$; for the girls, $r = .112 \pm .09$. This finding justifies the above procedure.

The ratios of activity during spring, summer, and autumn to that of winter have also been computed, on the basis of the equations given on page 83, and are shown in Table 15.

This table is to be read as follows: A boy six years of age will be 3 per cent more active during the spring than during the winter months, 7 per cent more active during the summer, and 14 per cent more active during the autumn, etc.

TABLE 15

SEASONAL VARIATIONS IN SLEEP MOTILITY

Ratio of Spring, Summer, and Autumn to Winter

Age	Boys			Girls		
	Spring	Summer	Autumn	Spring	Summer	Autumn
6	1.03	1.07	1.14	1.13	1.22	1.11
8	1.03	1.08	1.17	1.17	1.28	1.15
10	1.04	1.10	1.19	1.20	1.35	1.18
12	1.04	1.11	1.21	1.24	1.40	1.21
14	1.05	1.12	1.23	1.27	1.47	1.25
16	1.05	1.12	1.25	1.31	1.55	1.28
18	1.05	1.13	1.26	1.34	1.58	1.31

It is interesting to compare these results with those of Ladame (6) on seasonal variation in the duration of sleep. He found a minimum of sleep in January and February, the period of lowest sleep motility for our subjects, and a high submaximal duration during the summer, which roughly corresponds to the period of highest sleep motility found in our experiments. However, his maximum in April does not correspond to our findings. Of course there is no *a priori* reason for assuming a close correspondence between the voluntary duration of sleep and sleep motility. Haas, as reported by Kleitman, found that sleep in men was lighter in summer than in winter, which agrees with our findings.

An interesting comparison of our results may be made with seasonal variations in growth. The period of slow growth is from January to June, while maximal growth occurs between mid-July and mid-December. The period of slow growth, then, corresponds with that of minimum activity in sleep. Summer and autumn, the periods of maximum activity in sleep, correspond roughly to the period of rapid growth.

The period of minimal sleep activity corresponds with the period of depression in physical strength found by

Peaks and Lehman and by Pedersen. Dexter also states that the winter months are periods of low activity.

The following facts concerning seasonal variation in children's sleep are indicated by the results of this analysis:

1. There are definite seasonal differences in children's sleep.
2. There are marked sex and age differences in seasonal influence.
3. For both boys and girls winter sleep is the least motile.
4. For the boys autumn sleep is most active, showing a gain of 14 to 26 per cent over winter sleep. For the girls summer is the most active season, showing a gain of 22 to 58 per cent over winter.
5. The amount of seasonal influence is directly proportional to age.
6. Our results generally corroborate experiments on seasonal variations in growth, basal metabolism, and physical strength.

The "cause" of seasonal variations in motility is unknown. There are several possible interpretations of the differences in motility at different times of the year.

1. Temperature of the environment. The low correlations show that neither temperature nor relative humidity is an important factor. Barometric pressure has been suggested as a further possible influence. We have no data on this.
2. Activity during the day may differ sufficiently by seasons to affect motility at night. Both Karger's observations and our own find little to support such a claim. Extreme fatigue or any unusual deviation from the normal course of daily activity would likely influence the curve. Under our conditions such things were rarely seen.
3. Exposure of the skin to actinic sunlight. This, together with diet (sufficient vitamin representation) and calcium metabolism represent a large field of research on which comparatively little is known at present. Studies should be made comparing these physiological variables with sleep motility, particularly in children.
4. Change in irritability may be due to "adaptation" or change in the threshold level of the peripheral skin receptors, particularly

those involved in temperature discrimination. Little or nothing is known about these changes in relation to sleep motility.

5. Dr. Kenneth Blackfan, Professor or Pediatrics in the Harvard Medical School, has suggested in a conference on the problem that the low winter motility may be due to low-grade infections carried by children in winter but not in summer. There are many reasons for believing that this factor should receive further study. The almost *universal* character of the low motility in children makes this problem one of the utmost importance for further work.

8. CHANGES IN PATTERN IMMEDIATELY BEFORE ILLNESS

RESTLESS sleep is frequently looked for by physicians and parents as a symptom of threatening illness in children. Opportunity was presented to us to study this question, since a number of the children were forced to leave the experimental beds in the course of the various experiments for a stay in the hospital. Any complaint of *malaise* by a child at the Bureau leads to his being sent at once for medical examination. In some instances the child was able to return from the hospital after a few days, so that the record was resumed.

It was assumed that any significant alteration of the sleep pattern one or more nights before the medical examination might be taken as a concomitant of the illness. By revising the usual order of procedure and looking back at the records taken before the start of the sickness, we sought to determine how far in advance of acute symptoms any significant changes in motility had occurred.

There were sixteen such cases in which the medical records of Dr. J. M. Gettrost were available. His diagnoses were as follows: hyperpyrexia 2, serum sickness 1, septicemia 1, pharyngitis 2, tonsilitis 5, influenza 2, parotitis 1, scarlet fever 1, gastritis 1.

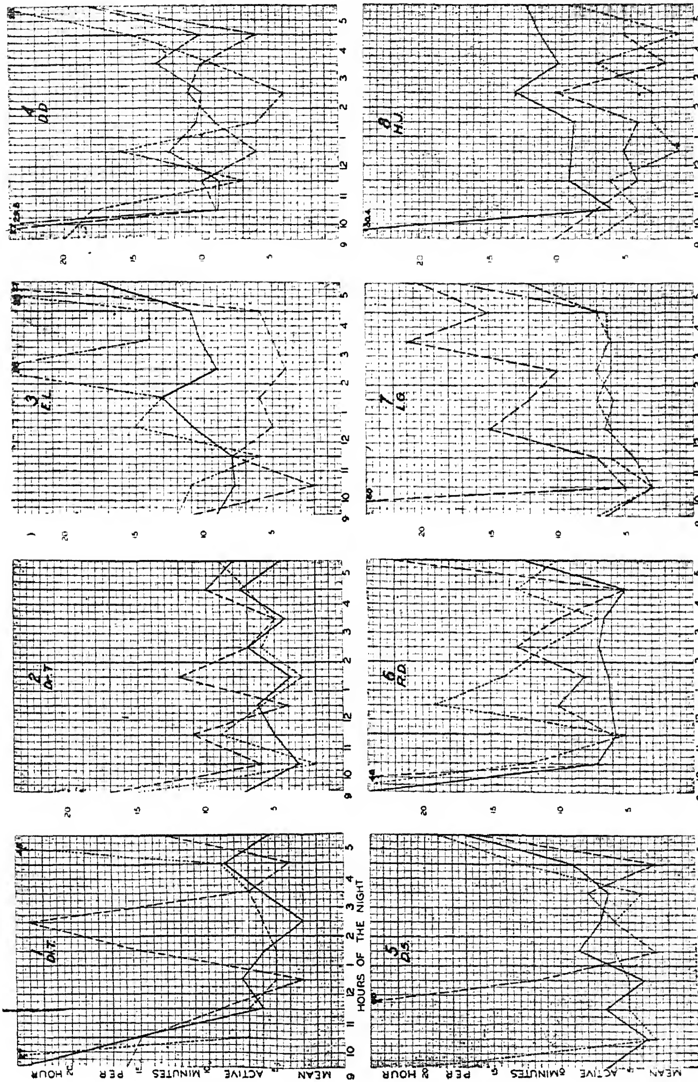
The normal curves were plotted in the manner described previously, based on the means by hours for normal nights up to and including the third night preceding the illness, since there appeared to be no significant change earlier than the second night preceding illness. In those cases where the data did not include more than two or three nights previous to the illness, a norm was computed from the series of nights following discharge from the hospital and return to the experimental beds. Against the norm we present the separate curves of the two nights immediately preceding the admission to the hospital for treatment.

The resulting curves are shown in Figs. 14 and 15. The normal sleep is indicated by a solid line, the first night preceding illness is plotted as a broken line, and the second night before the illness as a dotted line. Where the norm is taken from nights *following* an illness, this is represented by a dash followed by two dots.

The following case summaries are given as an aid to the interpretation of the curves.

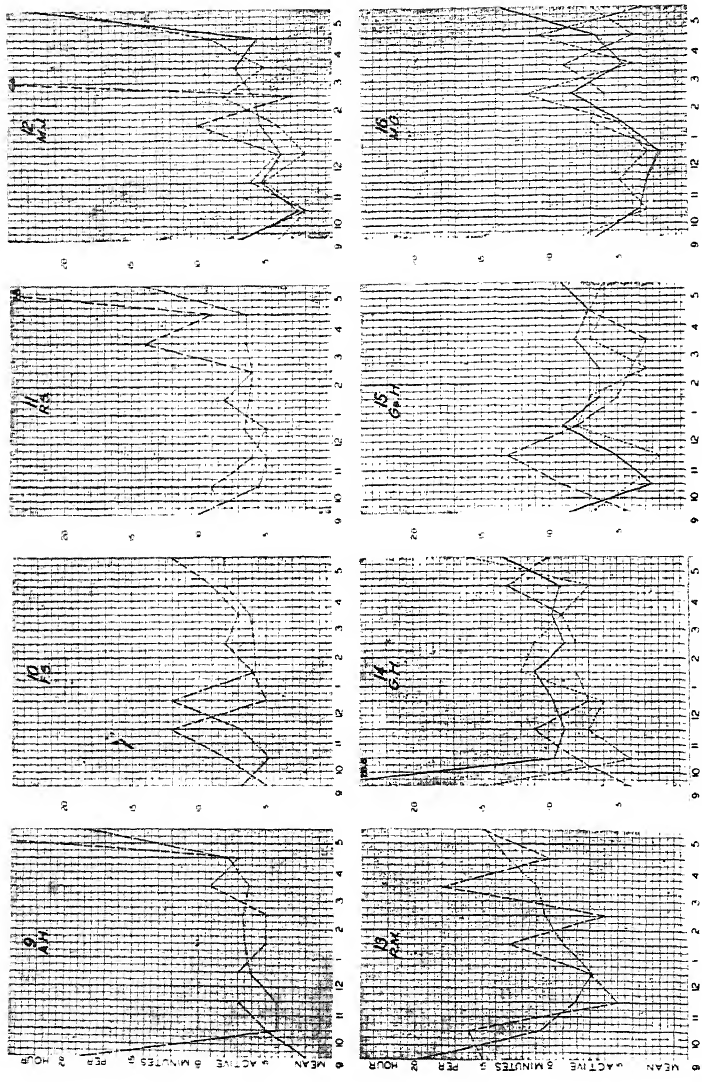
Case 1: Dl.T., girl, age 15, I.Q. 73. Committed for running away from home. Experiment III; 6 nights in experimental bed before hospitalization. Diagnosis, hyperpyrexia following a vaccination; recovery rapid. The curves show that two nights before the girl was committed to the hospital the sleep pattern underwent a very definite change, with still further accentuation of this difference on the night immediately preceding illness.

Case 2: Dr.T., girl, sister of Dl.T., age 11^6, I.Q. 88. Quiet and pleasant, normal personality; committed for running away from home and truancy. Experiment III; 6 nights in experimental bed before hospitalization. Diagnosis, hyperpyrexia; course of illness short, severity moderate, recovery rapid. In this case it will be noted that there is a distinct heightening of motility, particularly in the first five hours, for the two nights preceding admission to the hospital. Note the striking similarity in the characteristics of these curves.



CHANGES IN PATTERN BEFORE ILLNESS, CASES 1–8

FIG. 14



CHANGES IN PATTERN BEFORE ILLNESS, CASES 9–16

FIG. 15

Case 3: E.L., girl, age 15^6, I.Q. 102. Stable personality; adjusted well at the Bureau; committed for promiscuous immorality and pregnancy. Experiment VI, 7 nights in experimental bed before hospitalization. Diagnosis; serum sickness; mild, with rapid recovery. Note the general type of the normal curve in this case; also the striking differences between the two other curves.

Case 4: D.D., boy, age 13^4, I.Q. 93. Unstable, apparently psychopathic; committed for mental examination. Experiment VI; 2 nights in experimental bed before hospitalization. Diagnosis, septicemia; moderately severe, recovery rapid. Normal curve is based on 8 nights following return from the hospital.

Case 5: D.S., girl, age 9^4, I.Q. 77. Somewhat unstable; adjustment difficult at the Bureau; committed as a behavior problem. Experiment VI; 9 nights in experimental bed before hospitalization. Diagnosis, pharyngitis; short, acute, with rapid recovery. The first night before illness the child was active 60 minutes in each hour until 1:00 o'clock, and on the second night before, the beginning of the waking-up process started about an hour earlier than normal. The pattern of the second night differs distinctively from the normal.

Case 6: R.D., boy, age 13, I.Q. 87. Adjusted well at the Bureau; committed for stealing. Experiment VIII; 12 nights in experimental bed before hospitalization. Diagnosis, rhinopharyngitis; short, acute, with rapid recovery. There is a significant increase in motility for the two nights preceding illness, and a very definite change in the patterns.

Case 7: L.G., girl, age 14, I.Q. 73. Personality unstable; committed as a behavior problem. Experiment VII; 3 nights in experimental bed before hospitalization; normal curve represents 11 nights following illness. Diagnosis, acute follicular tonsilitis; recovery rapid. The night immediately preceding illness shows greatly increased activity.

Case 8: H.J., boy, age 17, I.Q. 55. Poor adjustment to normal environment; pretended to be ill much of the time; committed for repeated delinquencies including obscenity, stealing, etc. Experiment III; 7 nights in experimental bed before hospitalization. Diagnosis, follicular tonsilitis; mild, with rapid recovery. In this case both nights preceding illness show increased quiet,

the effect for the second night being somewhat greater than that for the first.

Case 9: A.H., girl, age 14, I.Q. 75. Stable personality; committed for truancy. Experiment VI; 1 night in experimental bed before hospitalization; normal curve taken from records following illness. Diagnosis, tonsilitis and pharyngitis; mild, with rapid recovery.

Case 10: F.S., boy, age 18, I.Q. 97. Quite normal but very proud and sensitive boy from a very poor family; committed for perpetrating a hold-up "just for a thrill"; had also played truant for the same reason. He made an excellent adjustment at the Bureau; his whole attitude changed, he responded to praise and responsibility, and became quite trustworthy. Subject in Experiment III; 1 night in experimental bed before hospitalization. Diagnosis, acute follicular tonsilitis; course short, with temperature from 98 to 102°; recovery rapid.

Case 11: R.S., girl, age 15^6, I.Q. 63. Stable personality; adjusted well at the Bureau; committed because she habitually wandered the streets at all hours. Experiment VI; 2 nights in experimental bed before hospitalization. Diagnosis, tonsilitis; mild, with quick recovery.

Case 12: M.J., girl, age 16, I.Q. 83. Unstable personality; difficult adjustment at the Bureau; committed for mental examination. Experiment VII; six nights in experimental bed before hospitalization. Diagnosis, influenza; mild, with rapid recovery. The differences in the curves here seem to be most striking in the latter part of the night. Note that on the second night before illness, the upward slope of the curve begins about 3:00 o'clock, whereas this takes place an hour earlier the second night previous. From about 2:30 this girl was apparently awake for the rest of the night.

Case 13: R.M., boy, age 17, I.Q. 78. Somewhat unstable; committed for drunkenness, abusiveness, and stealing. Experiment VIII; ill the day after the experiment started. Diagnosis, influenza; course short, with temperature from 98 to 104°; recovery rapid. Normal curve derived from 7 nights following discharge from the hospital.

Case 14: G.H., girl, age 14^8, I.Q. 105. Personality stable; committed for persistent lying and slovenly habits. Experi-

ment V; 12 nights in experimental bed before hospitalization. Diagnosis, epidemic parotitis; moderately severe, course long, convalescence slow. On the two nights preceding illness this girl was distinctly quieter during the first five hours.

Case 15: Ge.H., boy, age 7, I.Q. 100. Quite unstable; did not adjust very well at the Bureau; committed for habitual thieving. Experiment IV; 7 nights in experimental bed before hospitalization. Diagnosis, scarlet fever, course was long; severity moderate, and convalescence very slow. The curve shows very little change two nights preceding the illness, with a complete inversion of the pattern for the night immediately preceding diagnosis.

Case 16: M.G., girl, age 13^7, I.Q. 85. Personality of an instigator, getting others into trouble with herself; adjusted very well at the Bureau and was perfectly willing to do considerable work. Experiment III; 10 nights in experimental bed before hospitalization. Diagnosis, gastritis; acute but with rapid recovery. Note the characteristic change in the last half of the night.

A study of these figures reveals the following characteristics:

1. Nearly all cases show sharper peaks, representing concentrated periods of increased motility.
2. The number of these peaks is increased over the normal.
3. Curves are in general much more variable on the nights immediately preceding illness.
4. In many cases the first noticeable activity peak in the fore part of the night is shifted to an earlier hour.

We conclude from these studies that common types of sickness cause a change in the normal sleep motility curve, which is evident at least one and sometimes two or three nights previous to the time that active symptoms appear. These findings suggest that the technique of recording sleep motility might be utilized in children's hospitals as a procedure to assist the medical staff in observing the course of illnesses in children. The number of cases presented

here is small, and they are offered as indicative of a line of research that should be extended to larger numbers of cases with more careful records of correlative physiological and pathological variables for comparison with the motility trends.

9. CONCLUSIONS

1. THERE is little or no justification for the belief held by some that children may be classed into types: (a) those who sleep most soundly in the fore part, and (b) those who sleep best in the latter part of the night. There may be an occasional instance of either type, but these cases are rare.

2. The hourly motility distribution is a characteristic for an individual child that is stable to a high degree under normal routine living undisturbed by illness, emotional upsets, etc. The means are found, on the average, to be twenty to thirty times their own standard deviations. This is from four to six times the amount usually regarded as satisfactory to establish the reliability of an average. This fact establishes sleep motility as a function which can be utilized experimentally as an index of sickness and health and of such psychological influences as those derived from motion pictures and other variables.

3. Ten to fifteen consecutive nights is sufficient to give a norm or pattern for a child aged six to eighteen. This fact is established by (a) high correlation of odd-even nights; (b) stability, with narrow limits, of cumulative averages of both individuals and groups; (c) the proportional relation of the individual means of the active minutes per hour to their own standard deviations.

4. Temperature and relative humidity are not important factors, even within wide limits, in influencing hourly

motility. Our results agree with those found by Pratt, who used infants one to fourteen days old as subjects. None of the correlations exceeded .20.

5. Our results show significant age differences and individual characteristics at all ages from six to eighteen. Garvey found no significant individual differences in the activity patterns of preschool children, two and one half to four.

6. In general motility varies inversely with age, the younger children being more quiet sleepers than the older ones. This statement applies only to ages 6–18 years.

7. Below about ten and one half years there are no significant sex differences. After this age, sex differences are marked.

8. Active minutes (motility) is a more differential measure than the average length of the quiet periods between stirs, or any other measure of the sleep pattern derivable from our data.

9. From the evidence of small variability in pattern we conclude that significant pattern changes are not occasioned by variations in daily activities, environmental noises, diet, etc., under the conditions of our study.

10. In general we conclude that there is justification for the belief that the least motile and most recuperative sleep is indulged in during the first half of the stay in bed. Usually the period of greatest body immobilization occurs from 30 minutes to $1\frac{1}{2}$ hours after the child has retired. This point occurs earlier at certain seasons (winter and spring) than in others (summer and autumn).

11. There are significant seasonal variations in the sleep pattern, of sufficient magnitude to make it necessary for investigators of such functions as sleep motility to take due regard of the differences. Boys show a different change in pattern with season from that of girls.

12. The average child, aged six to eighteen, stirs or rearranges his posture one or more times during 8.7 minutes each hour. He spends about 1.3 hours of the normal night in "activity"—that is, some activity occurs in each of 78 minutes. The duration of the average quiet period varies with the individual and with the time of night. The average quiet period for all children is about 10.8 minutes. The distribution of lengths of quiet periods is of such form that the shorter the quiet period the more frequent will be its occurrence.

CHAPTER VI

THE INFLUENCE OF MOTION PICTURES

Un phénomène de sentiment ne se manifestera jamais que par le mouvement.—CLAUDE BERNARD.

1. INTRODUCTORY

IN previous chapters we have shown that it is possible to establish norms which can be used as a basis of comparison for the determination of the amount and type of influence on the sleep motility curves of various kinds of motion pictures. While children differ with respect to age, sex, season of the year, etc., yet we may determine a statistically reliable norm for an individual child and may use this as a standard of comparison for studying the motion-picture influence.

In order that the reader may understand clearly the data which we shall present in this chapter we shall first describe some special aspects of the procedure we followed.

In general the twenty children serving as subjects in any experiment were assembled immediately at the conclusion of the evening meal—that is at 6:20 P.M. They walked two blocks in a group to the theater, usually arriving there at about 6:30 P.M. The motion-picture program generally consisted of a feature picture, a comedy, and a news reel. The program lasted approximately two hours. The children were usually returned to the Bureau by 8:45, were made ready for bed, and retired promptly at 9:00. Thus it frequently happened that the arrival at the theater came at a time when the comedy, news reel, or feature was already being shown. The question arises, to what extent might this fact influence the child's perception of the continuity

of the story? Would the reaction to the picture have been the same had he entered the theater at the very beginning of the program? The only answer we can give to these questions is that some of the time they did see the pictures from the very start. Some of the time they did not. In any case, we believe that the general conditions under which these films were shown differ in no essential respect from those under which the average child views the average motion picture. It should be noted that in no case was the picture more than about one fourth through its exhibition and that even though there was late entry, in every case all children stayed through enough of the next performance to give a complete cycle of the story. The number of these cases of late entry was not large.

In general it may be said that the journey from the Bureau to the theater and return was orderly, the children were carefully supervised by at least two experimenters, one male and one female. The conditions attending the viewing of the film perhaps may best be described as uneventful.

During the series of experiments various groups of our children were taken to see a total of fifty-eight different motion-picture programs. These programs were unselected in the sense that we took them to see whatever picture happened to be shown at one of the two neighboring theaters. Other things being equal, we patronized the nearer of the two. In some cases it was necessary to travel in taxicabs about ten blocks to a different theater. This was inescapable because of the fact that the same film might be shown for more than one day at the one theater. This policy was adhered to throughout the experiments in order to conform to the principle discussed in Chapter I, namely, to maintain throughout the work the typical life situation under which children generally attend motion pictures.

2. "HOLIDAY" EFFECT

THE question immediately arises as to whether the change in sleep pattern following movie attendance was due primarily to the influence of the motion picture or to sundry influences wrought by the child's presence in the crowd of the theater, the music, the trip for two hours away from the Bureau, etc. In order to determine this point we made the following experiment.

The children were assembled at the usual hour and were placed in a half dozen automobiles loaned for the occasion by members of the Bureau staff, by the experimenters, and others. Instead of going to the movie, the children were taken for a ride through the crowded streets of downtown Columbus, where they were enabled to window-shop and to enjoy the lights and the scenes presented to them in a trip through the heart of the city; then they were taken north about three miles to the campus of the University, thence along the beautiful river drive, through the exclusive residential suburb of Arlington, then back to the Bureau. The total trip consumed approximately two hours. The children, during this ride, were permitted to laugh and talk and enjoy themselves in the fashion characteristic of any outing or excursion. They all testified that they enjoyed the ride to a marked degree. They prepared for bed at the usual hour.

An analysis of the figures presented in Tables 48 and 49 shows that eighteen of the twenty children slept a little more quietly following the trip than was their normal. Two boys behaved rather boisterously at the conclusion of the trip and continued their enthusiasm, engaging in pillow fights and such activities until an hour and sixteen minutes after retiring. Of course their records for this period are not

records of sleep motility although the incident does illustrate the perseverative tendency. Excluding the figures for these two boys, the group of boys as a whole showed an increase of only 0.9 active minute per hour for the entire night after this automobile ride, over their normal average. Even when the records of the two active boys are included, the entire group showed an increase of only 1.7 active minutes per hour for the entire night.

No such disturbance occurred in the case of the girls. We note from Table 48 that whereas the normal mean of the group of ten girls is 8.8 active minutes per hour, under the holiday effect the mean on the same group is 8.9. These changes in motility do not compare in magnitude with those following movie attendance (which will be brought out in a later section).

Based on the above considerations, together with our observations from accompanying these children to the fifty-eight shows, we are led to the conclusion that the holiday effect is not an important factor in the total change in pattern incidental to the viewing of the motion picture. Since most of the groups of children went repeatedly to the same theaters, it is doubtful if the novelty of the trip out had any appreciable influence after the first night or two.

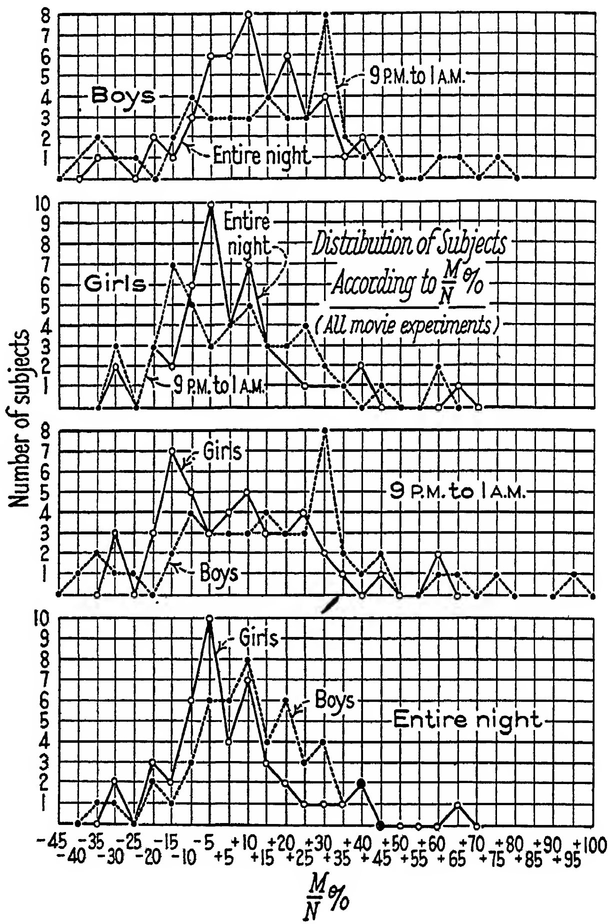
3. General Characteristics of Movie Sleep Curves

It may be said in general that the most outstanding difference between the sleep patterns after the movie as compared with the normal lies in the significant change in the first four or five hours after the entry into bed. Usually this change is marked by increased motility. In certain cases, particularly with the girls and with the younger chil-

dren of both sexes, there may be a lessening of activity in the fore part of the night. The movie influence therefore may act either to increase the mean hourly activity or to decrease it. In the case of those children who show marked influence from the movie we may observe that whereas in the normal sleep the point of minimal motility is reached within the first 15 minutes to an hour and a half, in the movie sleep the minimal point is not reached until distinctly later—in some cases within the second, third, and even the fourth hour. The movie influence generally affects the first four or five hours of the night distinctly more than the last half of the night. As we have shown in Chapter V, the fore part of the night is a period of least motility, and from reasons given in Chapter I, the time in which the sleeper engages in the most restful and recuperative sleep of the night.

We present following Figs. 16 and 17 to show the distribution of the amounts of increased and decreased motility for all subjects taking part in all experiments. From the cumulative percentile curves (Fig. 17) one may read off directly the percentage of all children showing any given amount of increase and decrease between 9:00 and 2:00, and also for the entire night. These figures are read as follows:

Approximately 60.5 per cent of the ninety-four children on whom we have movie data show increased motility, whereas 39.4 per cent show a decrease. Of the 60 per cent showing increases, 45.5 per cent show increases of 10 per cent or less; 26.3 per cent show 11 to 20 per cent; 14.1 per cent show 21 to 30 per cent; 12.3 per cent show 31 to 40 per cent; and less than 1 per cent show more than 40 per cent. Of the thirty-seven children who show decreases it is interesting to note that 67.5 per cent show 10 per cent or less decrease; 21.3 per cent show 11 to 20 per cent decrease; while only 10.8 per cent show decreases in excess



Boys
9 P.M. to 1 A.M.
Entire night
Girls
Entire night
Distribution of Subjects According to $\frac{M}{N}$%
(All movie experiments)
9 P.M. to 1 A.M.
Girls
9 P.M. to 1 A.M.
Boys
Girls
Boys
Entire night
Number of subjects
-45 -40 -35 -30 -25 -20 -15 -10 -5 +5 +10 +15 +20 +25 +30 +35 +40 +45 +50 +55 +60 +65 +70 +75 +80 +85 +90 +95 +100
$\frac{M}{N}$%

FIG. 16

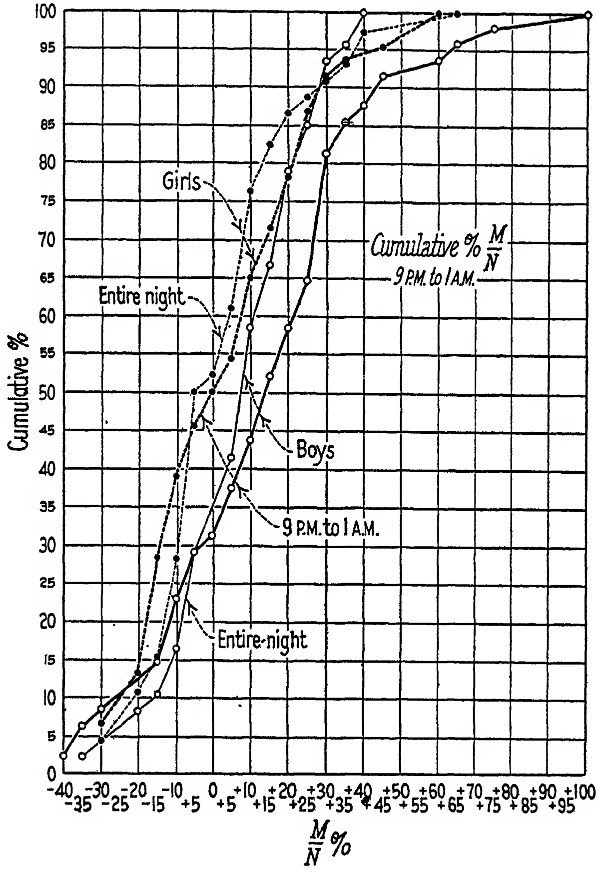

Cumulative %
Girls
Entire night
Boys
9 P.M. to 1 A.M.
Entire-night
Cumulative % M/N
9 P.M. to 1 A.M.
M/N %

FIG. 17

of 20 per cent. The exact figures are 8.1 per cent show decreases of 21 to 30 per cent, and 2.7 per cent show decreases as great as 35 per cent. In other words, only 12.8 per cent of all children show more than 10 per cent quieting after the movies, whereas 33 per cent of all the children show more than 10 per cent increase. Roughly about two and one half times as many show a significant increase as show a significant decrease in motility. In interpreting the above tables and graphs the reader should refer to the theoretical considerations presented in an earlier chapter of this monograph. We shall present in Chapter VII additional evidence which will assist in determining the amount of increase or decrease in motility which may be regarded as *physiologically* and *psychologically* significant. Jacobson has asserted that hypertension in any degree is significant. We present the above distributions to indicate that many children show increased restlessness within the critical time of the night, namely, the first half, which deviates far enough from their own norms that the deviation represents a *statistically* significant change. In the next chapter we shall show that both decreased and increased motility following movies are equally significant.

In order to ascertain whether the change in motility is related to mental ages and I.Q.'s of the subjects participating in Experiments II, III, V, and VI we made scatter plots of the mental ages and the I.Q.'s separately against the ratio M/N. This ratio represents the mean motility under movie conditions divided by mean motility under normal conditions. In a certain sense it is bad to pool the entire series of movie nights and relate them to the norm as M/N. The reason for this is that the variation under the M (movie) condition is so great in comparison to N (normal) conditions, and may even become so attenu-

ated by the algebraic summing of plus and minus differences that the true status for any single child is not represented by any such single figure, standing for a hypothetical composite M. Four illustrative cases taken at random are shown with their N's in Table 16.

TABLE 16

M/N RATIO FOR FOUR RANDOM CASES, EXPERIMENT II

Boy	R.S.		R.G.		Girl L.C.		H.B.	
Age	13^{0}		16^{0}		12^{5}		17^{8}	
Normal	13.82		8.38		12.16		9.86	
	Movie	M/N	Movie	M/N	Movie	M/N	Movie	M/N
M_1	21.4	1.55	12.2	1.46	9.6	0.79	13.0	1.32
M_2	16.4	1.19	14.2	1.69	14.6	1.20	9.2	0.93
M_3	22.6	1.66	11.6	1.38	16.8	1.38	6.2	0.63
M_4	17.4	1.26	16.2	1.93	12.4	1.02	5.2	0.53
M_5	21.4	1.55	10.2	1.22	14.6	1.20	9.6	0.97

It will be seen that each movie presents a special case for each child and should be considered singly and individually. The use of the composite ratio M/N and the frequency distribution of these we present to show (1) that *some* children exhibit an *increased* motility (hypertension) in sleep after movies which is of sufficient magnitude to warrant drastic measures; (2) *other* children may, on the whole, not show a single instance of increase, but *always* a *decreased* motility after movies. What conclusion can we draw in such a case? We shall present an answer to this question in the next chapter.

The mental age range extended from 7 years to 17^{6}. The I.Q. range was from 40 to 120. An inspection of Tables 17 and 18 reveals no significant relationship between either the M/N ratio and mental age or I.Q. If we make the same comparison for the chronological ages of our subjects, we do discover a significant trend, which will be discussed in greater detail in Section 4 of this chapter. Why do the

TABLE 17

RELATION OF MOVIE INFLUENCE TO MENTAL AGE

M/N Activity Ratio against M.A., 9:00 P.M. to 2:00 A.M., Experiments II, III, V, VI

M/N Ratio in Per Cent	Mental Age (Stanford-Binet)												Total
	7	8	9	10	11	12	13	14	15	16	17	18	
80													
70								1			1		2
60		1											1
50									1				1
40						1		1					2
30						1							1
20		2	1	4	2	1	1			1			12
10	1	1	2	1	4				1	2			12
0		2	1		2	1	4	1	1	1	1		14
−10	2	2	3	1	3		1						12
−20		2		3	3			1				1	10
−30		1			1								2
−40		1		1									2
Total	3	12	7	10	15	4	6	4	3	4	2	1	71

TABLE 18

RELATION OF MOVIE INFLUENCE TO INTELLIGENCE QUOTIENT

M/N Activity Ratio against I.Q., 9:00 P.M. to 2:00 A.M., Experiments II, III, V, VI

M/N Ratio in Per Cent	I.Q.									Total
	40	50	60	70	80	90	100	110	120	
70							1			1
60							1			1
50							1	1		2
40						1			1	2
30							1			1
20		1			4	2	3	1		11
10	1				3	3	5	1		13
0						4	4	4		12
−10			2	2	4	3	1			12
−20				1	4	1	2	1	1	10
−30					1			1		2
−40							1	1		2
Total	1	1	2	3	16	14	20	10	2	69

ratios show little or no relation to mental age and brightness level, but a significant relation to chronological age? A possible hypothesis is that the determination of mental age and I.Q. is made on the basis of functions of the neo-pallium, whereas the motion-picture influence may be based on the extent to which the whole nervous system is reflexly excited by the impression received. The supplementation of visual perception, it must be remembered, is largely dependent upon the fund of general information accumulated through past experience, and this is not necessarily directly correlated with mental age.

4. DIFFERENCES INCIDENTAL TO AGE, SEX, AND SEASON

TABLE 19 presents the comparative results on seventy-nine children who participated in Experiments II, III, V, and VI. A study of these figures reveals the following facts.

TABLE 19

AGE AND SEX DIFFERENCES IN MOVIE INFLUENCE

Activity Means and Movie/Normal Ratios, First Five Hours and Entire Night, Experiments II, III, V, VI

Age Group	Subjects	First Five Hours Mean Hourly Activity				Entire Night Mean Hourly Activity			
		Pre-Movie	Movie	Post-Movie	M/N	Pre-Movie	Movie	Post-Movie	M/N
		Boys							
$6-10^{6}$	10	6.18	5.91	5.67	0.956	6.51	6.27	5.25	0.963
$10^{7}-13^{6}$	17	8.92	10.68	9.64	1.197	8.74	9.63	8.80	1.101
$13^{7}-18^{0}$	14	9.48	12.17	11.47	1.283	9.03	10.67	10.62	1.18
Total	41								
		Girls							
$6-10^{6}$	10	6.14	5.83	7.19	0.949	6.82	6.35	6.64	0.931
$10^{7}-13^{6}$	9	8.47	9.12	9.77	1.076	8.50	8.91	9.66	1.048
$13^{7}-18^{0}$	19	9.74	9.77	9.06	1.003	9.33	9.44	8.34	1.011
Total	38								

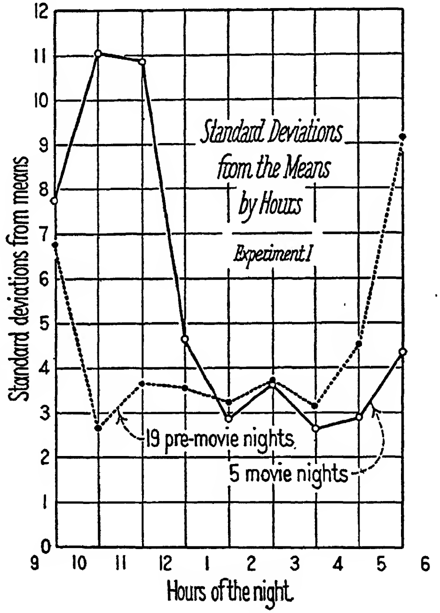

Standard Deviations from the Means by Hours
Experiment I
Standard deviations from means
12
11
10
9
8
7
6
5
4
3
2
1
0
9
10
11
12
1
2
3
4
5
6
Hours of the night
19 pre-movie nights
5 movie nights

FIG. 18

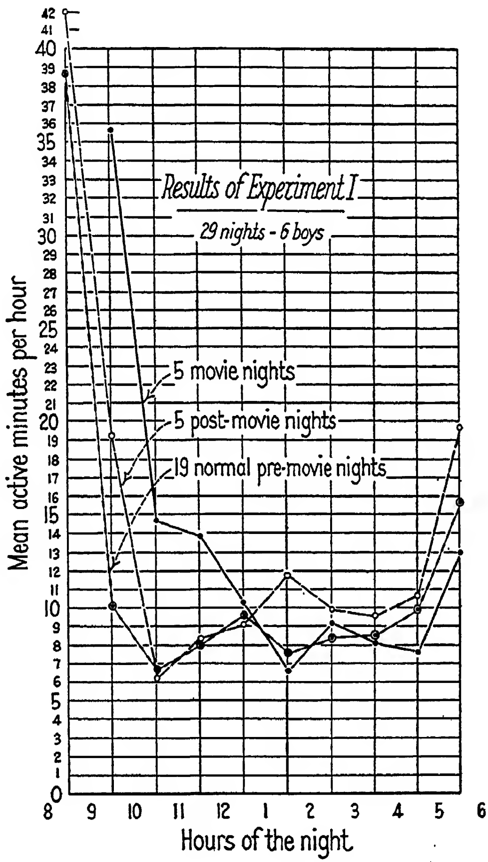

Results of Experiment I
29 nights - 6 boys
5 movie nights
5 post-movie nights
19 normal pre-movie nights
Mean active minutes per hour
Hours of the night
8 9 10 11 12 1 2 3 4 5 6

FIG. 19

There are characteristic age differences which show that the same trends occur in the case of the movies as were pointed out in normal sleep and seasonal variations; namely, after the movies the younger children show less activity than the next higher age group, and the latter in turn less than the oldest age group. This generalization holds good for both sexes, yet there are extremely significant sex differences. These differences are greater in the case of movie sleep than they were for normal sleep. It should be noted that the youngest group of these children shows almost no sex difference. The upper limit of this group is 10^6.

The movie influence is not limited to those nights in which the motion picture was seen. Testimony to this fact is shown by a study of the columns headed Post-Movie. Here again it is seen that the carry-over effect is significantly greater for the girls than for the boys. In normal sleep the ratio of the oldest to the youngest boys is 9.48/6.18, or 1.5339. In movie sleep the ratio of oldest to youngest boys is 12.17/5.91, or 2.0592. The motion-picture effect thus increases the difference between older and younger boys. These figures apply to the first five hours. For the whole night the corresponding ratio is 9.03/6.51, or 1.387, and for movie sleep it is 10.67/6.27, or 1.701. For the girls in the first five hours the normal ratio of oldest to youngest group is 9.74/6.14, or 1.588, and for the movie it becomes 9.77/5.83, which is 1.675.

If one considers the age group 6 to 10^6, it will be noted that the boys show a consistent drop in pre-movie, movie, and post-movie averages, both for the hours 9:00 to 2:00 and for the entire night. The youngest age group of girls fails to show this consistent trend, which is a further sex difference.

Table 20 presents still a different type of analysis, comparing the movie influence on boys and girls by age groups

TABLE 20

AGE AND SEX DIFFERENCES IN MOVIE INFLUENCE

Frequency and Range of Activity Increase, First 5 Hours of the Night, Experiments II, III, V, VI

Age Groups	Boys				Girls			
	Number of Cases	Per Cent of Cases Showing M > N	Range Per Cent	Mean Movie Increase Per Cent	Number of Cases	Per Cent of Cases Showing M > N	Range Per Cent	Mean Movie Increase Per Cent
6^6–10^6	9	44.4	3.1–62.6	24.9	10	20.0	2.9–23.0	12.9
10^7–13^6	16	87.5	4.7–97.4	24.9	8	75.0	5.8–20.4	11.2
13^7–18^0	13	84.5	12.4–71.3	28.6	19	42.0	3.6–56.5	18.7

in the same experiments (II, III, V, and VI). We note from this table that the average movie increase in the case of all boys of all ages is 26.46 per cent, while for all girls of all ages this figure is 14.26 per cent. The ratio of these two figures is 1.8555. Boys of the above ages show 85.5 per cent greater increased motility in the first five hours of the night than girls of like ages. Boys older than 10^6 show increased motility in 86 per cent of the twenty-nine cases, while boys aged 6 to 10^6 show increased motility in 44 per cent of the nine cases in this age group. We may also note from this table that only one girl in five below age 10^6 shows an increase, while three girls in four between the ages of 10^7 and 13^6 show an increase; and less than half of the girls in the age group 13^7 to 18 show an increase.

It will be seen from a study of Table 20 that an average increase of 25 per cent in movie sleep over normal sleep is half the increase in motility incidental to the seven years of normal growth from eight to fifteen in the case of the boys, and represents in the case of the girls about one quarter of the change incidental to this much growth (cf. Table 19).

From the above considerations we conclude that the motion-picture influence on sleep motility is minimal before 10^6 chronological age is attained. There are a few individual exceptions to this generalization.

We present Table 21 to indicate the comparison of the relative movie-normal ratios in an experiment conducted in the summer (II) with those of a winter experiment (III). From a comparison of the ratios of the means of normal and movie in winter and summer for both sexes, we conclude that in these two experiments the group movie influence seems to be consistent regardless of the absolute change in the normal motility pattern incidental to season.

TABLE 21

SEASONAL AND SEX DIFFERENCES IN MOVIE INFLUENCE

Mean Total Activity, Movie/Normal Ratios, and Summer/Winter Ratios, First Five Hours of the Night, Experiments II and III

Experiment II, July–August, 1929

Hour	Boys		Girls	
	Normal	Movie	Normal	Movie
9	20.9	28.6	26.4	27.9
10	5.7	6.6	6.9	7.5
11	6.5	8.9	6.5	6.7
12	7.7	9.7	8.2	7.6
1	6.8	7.3	8.8	8.9
Total	47.6	61.1	56.8	58.6

Experiment III, January–March, 1930

Hour	Boys		Girls	
	Normal	Movie	Normal	Movie
9	11.4	15.9	13.2	15.4
10	4.0	5.3	5.2	3.8
11	6.1	5.3	4.8	5.0
12	6.7	8.7	5.1	5.2
1	5.7	6.8	6.1	5.7
Total	33.9	42.0	34.4	35.1

	Boys	Girls
Experiment II	$\frac{M}{N} = \frac{61.1}{47.6} = 1.283$	$\frac{58.6}{56.8} = 1.031$
Experiment III	$\frac{M}{N} = \frac{42.0}{33.9} = 1.238$	$\frac{35.1}{34.4} = 1.020$
$\frac{\text{Summer N}}{\text{Winter N}}$	$\frac{47.6}{33.9} = 1.404$	$\frac{56.8}{34.4} = 1.651$
$\frac{\text{Summer M}}{\text{Winter M}}$	$\frac{61.1}{42.0} = 1.454$	$\frac{58.6}{35.1} = 1.669$

Table 22 shows the means and sigmas for normal and movie periods in autumn, winter, and spring. This table is presented to show the relative sizes of the standard deviations of the distributions and of the means. It will be noted

TABLE 22

SEASONAL AND SEX DIFFERENCES IN MOVIE INFLUENCE

Normal and Movie Activity Means and Sigmas, Autumn, Winter, and Spring

Season	Experiment	Mean Hourly Activity	Sigma Dis.	Sigma Mean	Subjects	Nights
NORMAL						
Boys						
Winter	III, VII	7.677	2.388	0.2158	27	19
Spring	IV, V	7.966	2.288	0.1693	46	19
Girls						
Winter	III, VII	6.744	2.255	0.2032	27	19
Spring	IV, V	8.477	2.377	0.1806	46	19
MOVIE						
Boys						
Winter	III	7.855	2.922	0.2522	9	15
Autumn	VI	8.933	3.288	0.4271	10	6
Girls						
Winter	III	6.900	1.644	0.1314	10	15
Autumn	VI	7.833	2.577	0.3385	10	6

that the absolute differences of the means are small. However, it should be remembered that whereas the means of the normal series are true means (empirical motility averages), the movie means are obtained by what amounts essentially to a process of algebraic summing, *i.e.*, adding increases and decreases, which gives an average utterly unrepresentative of the real changes which occurred in the individuals who comprise the group. The measures of dispersion, however, are significant. They can be interpreted as indicating the limits within which the true values lie. The emphasis should be placed upon the effect of the movie on individual children, rather than on the groups, in interpreting these data.

5. RESULTS OF THE VARIOUS MOVIE EXPERIMENTS

Experiment I

THIS experiment made use of ten boys as subjects in order that we might give a preliminary tryout to our apparatus and to ascertain what to expect in the way of results following the motion picture. Pursuant to this aim the general plan of the experiment, as will be noted in Table 7, consisted of 19 normal nights, followed by 5 consecutive movies, and in turn by 5 post-movie nights. The following movies were seen in the order given: "Weary River," "The Night Bird," "Revenge," "Topsy and Eva," and "Saturday's Children."

From Table 1 it will be noted that the mean age of these boys was about fifteen years.

TABLE 23

RESULTS OF EXPERIMENT I BY HOURS

Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Boys [1]

Hours of the Night	Pre-Movie	Movie	Post-Movie
8	38.7		42.0
9	10.1	35.7	19.2
10	6.7	14.6	6.2
11	8.0	13.8	8.2
12	9.5	10.1	9.1
1	7.5	6.9	11.7
2	8.3	9.1	9.8
3	8.4	8.1	9.6
4	9.9	7.5	10.6
5	15.7	13.0	19.6
Totals	122.8	118.8	146.0
Means	12.3 *	13.2	16.2
Sigma dis.	1.11		
Sigma mean	0.254		

* The means by hours and by individuals do not always check (cf. Table 24 and succeeding experiments). The discrepancies are small and are accounted for by the fact that they are the result of averaging averages horizontally and vertically and of dropping decimals.

[1] Only boys were used in this experiment.

TABLE 24

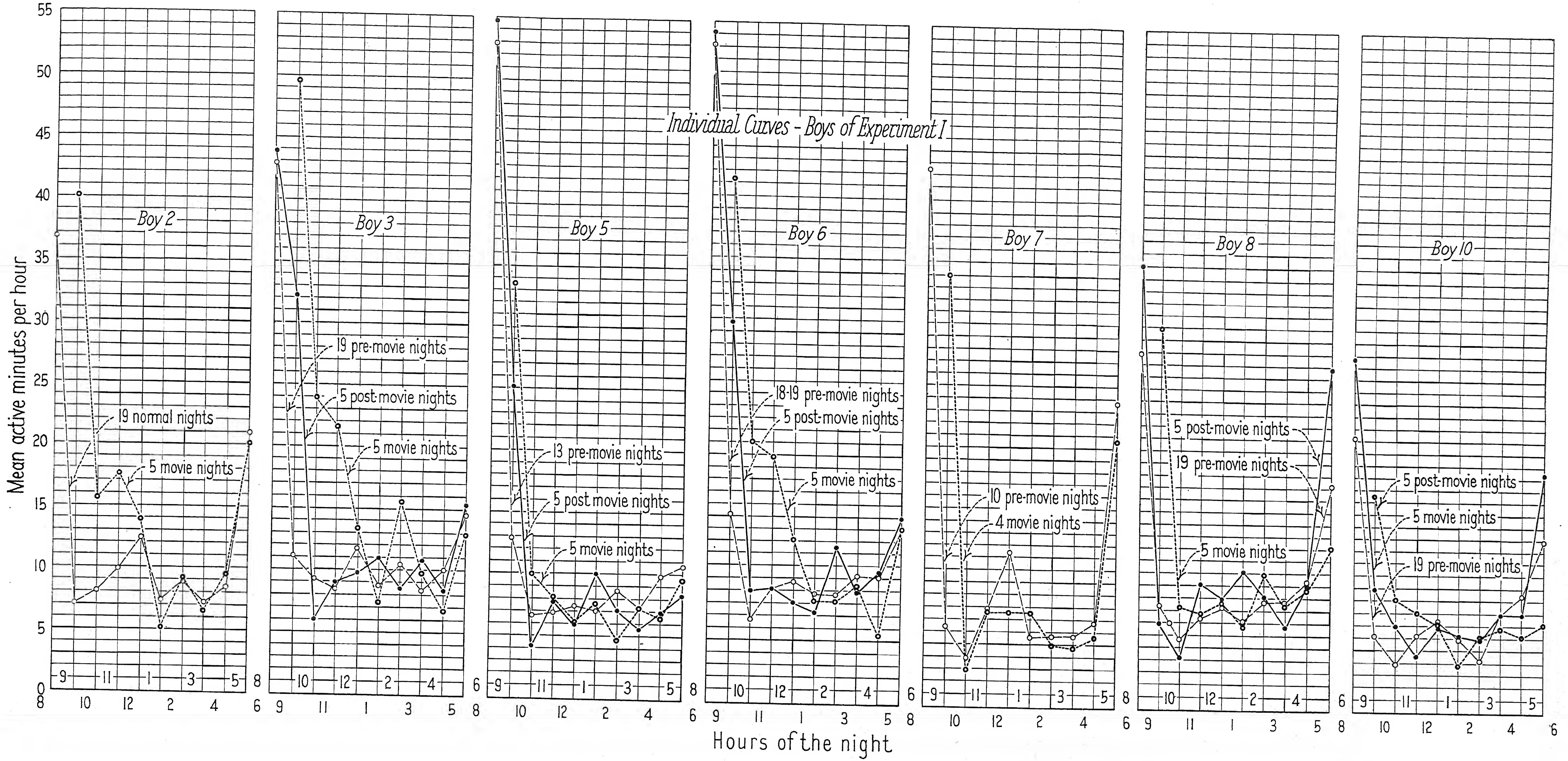
RESULTS OF EXPERIMENT I BY SUBJECTS

Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods; Boys [2]

Subject No.	Pre-Movie	Movie	Post-Movie
2	12.9	15.4	21.1
3	13.7	18.1	17.2
5	13.2	10.5	15.1
6	14.2	15.6	17.9
8	11.3	11.6	14.7
10	8.8	8.1	11.7
Totals	74.1	79.3	97.7
Means	12.4	13.2	16.3

Tables 23 and 24 present the results of the pre-movie, movie, and post-movie periods by hours and by subjects in this experiment, while Figs. 18, 19, and 20 show the curves of mean active minutes for all hours. It will be noted that during the period of the normal nights the children retired at 8:00 P.M. During the movie series they retired at 9:00. In all subsequent experiments the hour of retiring was kept uniform. It is interesting to note that the 8:00–9:00 hour shows a much larger number of active minutes than in those cases where 9:00–10:00 was the first hour in bed. Nevertheless the normal curve drops to its minimum at 10:00 P.M. and shows the same general characteristics referred to previously (Fig. 11). The movie curve, however, starting at 9:00 P.M., drops much less in the next two hours and does not attain its minimum until the fifth hour in bed, or the 1:00 o'clock hour. From this low point it follows the normal curve very closely to 3:00 A.M. and drops slightly below it for the remainder of the night. The curve of the five post-movie nights lies between the normal and movie curves, dropping to its minimum at the same hour, 10:00, as the pre-movie series, crosses the movie curve at about

[2] Only boys were used in this experiment.



Individual Curves - Boys of Experiment I
Mean active minutes per hour
Hours of the night
Boy 2
19 normal nights
5 movie nights
Boy 3
19 pre-movie nights
5 post-movie nights
5 movie nights
Boy 5
13 pre-movie nights
5 post movie nights
5 movie nights
Boy 6
18-19 pre-movie nights
5 post-movie nights
5 movie nights
Boy 7
10 pre-movie nights
4 movie nights
Boy 8
5 post-movie nights
19 pre-movie nights
5 movie nights
Boy 10
5 post-movie nights
5 movie nights
19 pre-movie nights

FIG. 20

12:30, and throughout the remainder of the night shows itself to be slightly higher than the normal. The general increase in motility throughout the night is particularly significant, since we might expect on the contrary a decrease in motility due to the loss of the customary first hour's sleep between 8:00 and 9:00, as will be brought out in the chapter on sleep deprivation.

It will be noted that the significant increments in activity of the averages for the first half of the night during the movie series are not compensated for in the last half of the night. It should also be noted that there is a striking carry-over of the movie influence into the five nights following.

From the curve of standard deviations in Fig. 18 it will be noted that the variability in the first half of the night is significantly greater under the movie than under the normal condition, and that these are directly proportional to the size of the hourly means.

A study of the results of this experiment indicates the desirability of keeping constant the time of retiring both for normal and movie nights.

Based on the results given above we were led to suppose that the movie effects would be large when the experiment was repeated on additional groups with the purpose of securing larger numbers and utilizing both sexes and different ages. Consequently we decided to vary the procedure in the next experiment.

Experiment II

This experiment ran from July 15 to August 21, 1930, inclusive. The plan was, first, ten normal nights, followed by ten movies: "The Barker," "The Dummy," "Hey, Rube," "Chinatown Nights," "On the Trail of the Horse Thieves," "Why Be Good," "Submarine," "The Patent

Leather Kid," "Hole in the Wall," and "Mother Knows Best." This movie series was followed by ten post-movie nights. These in turn were followed by five movies: "Sunrise," "Thunderbolt," "The Red Dance," "Fashions of Love," and "Red Hot Speed," and the experiment was concluded with five post-movie nights.

Our purpose in the arrangement of this experiment was to increase the length of the movie series in order to determine the extent to which the movie influence might summate. This longer series was then followed by a long stretch of ten normal nights in order to permit the children to recover from the influence, and this in turn was followed by a shorter series of five movies in order to permit us to check on the return of the influence.

Tables 25 and 26 present the results of this experiment, giving the means by hours and for the entire night by sub-

TABLE 25

RESULTS OF EXPERIMENT II BY HOURS

Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys					Girls				
	Pre-Movie	Movie 1	Post-Movie 1	Movie 2	Post-Movie 2	Pre-Movie	Movie 1	Post-Movie 1	Movie 2	Post-Movie 2
9	20.9	28.6	13.0	19.7	18.3	26.3	28.2	16.8	20.9	16.7
10	5.7	6.6	6.6	5.9	5.1	6.9	7.5	4.8	4.6	5.1
11	6.5	8.9	7.4	7.9	6.9	6.5	6.7	4.8	4.7	5.5
12	7.7	9.7	9.3	8.6	9.9	8.2	7.6	6.5	5.6	6.7
1	6.8	7.3	7.2	7.6	8.0	8.8	8.9	6.0	5.8	6.4
2	7.4	7.4	8.7	8.3	7.3	8.5	8.2	7.1	5.4	7.5
3	8.7	8.6	8.1	7.3	9.2	7.8	8.8	6.5	7.6	6.2
4	7.8	8.5	8.2	8.8	9.3	7.7	8.4	7.1	5.7	7.0
5	8.0	8.4	9.0	9.1	8.4	9.8	11.3	9.3	8.1	9.2
Totals	79.5	94.0	77.5	83.2	82.2	90.6	95.6	68.9	68.4	70.3
Means	8.84	10.44	8.61	9.24	9.13	10.07	10.6	7.66	7.60	7.81
σ dis.	1.01					0.98				
σ mean	0.319					0.309				

TABLE 26

RESULTS OF EXPERIMENT II BY SUBJECTS

Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods; Sexes Separate

Subject No.	Boys					Girls				
	Pre-Movie	Movie 1	Post-Movie 1	Movie 2	Post-Movie 2	Pre-Movie	Movie 1	Post-Movie 1	Movie 2	Post-Movie 2
1	5.3	7.3	4.2	3.2	4.9	8.7	9.4	8.2	7.8	8.5
2	7.4	8.7	5.9	7.6	7.1	10.2	10.9	7.8	8.0	8.4
3	8.0	7.6	4.8			10.7	12.1	10.6	9.8	13.1
4	13.1	16.4	12.1	13.5	13.5			6.3	5.9	5.7
5	7.4	10.4	8.4	7.1	6.9	8.4	9.9	8.4	8.2	7.9
6	8.3	10.2	10.7	9.7	10.9	9.4	9.1	3.7	3.8	3.9
7	11.9	12.7	11.6	13.0	10.8	12.4	12.2	10.9	10.0	9.8
8	9.5	11.4	8.7	10.4	8.9	10.1	11.0	6.3		8.9
9	8.2	9.6	8.0	8.0	8.4	9.9	9.9	8.8	9.1	8.2
10	9.1	10.1	9.3	9.9	9.3	10.7	9.9	5.2	6.0	4.8
Total	88.2	104.4	83.7	82.4	80.7	90.5	94.4	76.2	68.9	79.2
Mean	8.8	10.4	8.4	9.2	9.0	10.1	10.5	7.6	7.7	7.9

jects. It will be noted that on the average the boys show a significant increase in the first movie series over the normal and that the movie effect again carries over somewhat into the post-movie period; although the post-movie *average* is actually slightly lower than the normal. From this new low level the second movie series introduces a further increase from 8.61 to 9.24, which seems to persist in the second post-movie series, where there is an average of 9.23 active minutes per hour. For the ten girls we note that there is relatively small movie increase on the whole, followed by a large decrease in the first post-movie period. It is surprising that this decrease continues through the second group of five movies and shows but very slight upward trend in the second post-movie series.

How shall we interpret this finding? It will be noted that the average for post-movie 1 for the girls is even lower than that for their pre-movie period. It may be that the failure

of the second series of movies to increase this average indicates a phenomenon somewhat analogous to the failure of a stimulus to start a propagated disturbance in nerve or muscle during the refractory phase. The movie influence here clearly exerts a depressor effect which carries over into the first post-movie period, and also reduces the effects of the second movie series.

Here again we feel impelled to call attention to the fact that average figures such as these should be interpreted with great care. We call attention particularly to the fact that individual variations (increase for some, decrease for others) are minimized or completely lost sight of by the process of averaging and that the tendency will be to reduce and never to exaggerate the true state of affairs. This warning should be borne in mind in connection with all the summary tables of this type in experiments to follow. The reader can get a good idea of the individual variations involved by a careful study of Table 26 and the other summary tables by subjects.

Experiment III

Experiment III began with eleven normal nights and ended with ten post-movie nights. Between these two series the children were taken in groups of ten and twenty to see a total of twenty-four different pictures. These pictures were: "Thirteenth Chair," "One Hysterical Night," "Salute," "The Racketeers," "Sailor's Holiday," "Lucky Star," "Marianne," "The Valiant," "Girl Overboard," "The Girl from Havana," "Mysterious Island," "Christina," "Why Leave Home?" "Through Different Eyes," "The Seven Faces," "Words and Music," "Sunny Side Up," "Hold Your Man," "The Four Devils," "Barnum Was Right," "Tonight at Twelve," "Señor Americano," "Flight," and "Songs of Kentucky."

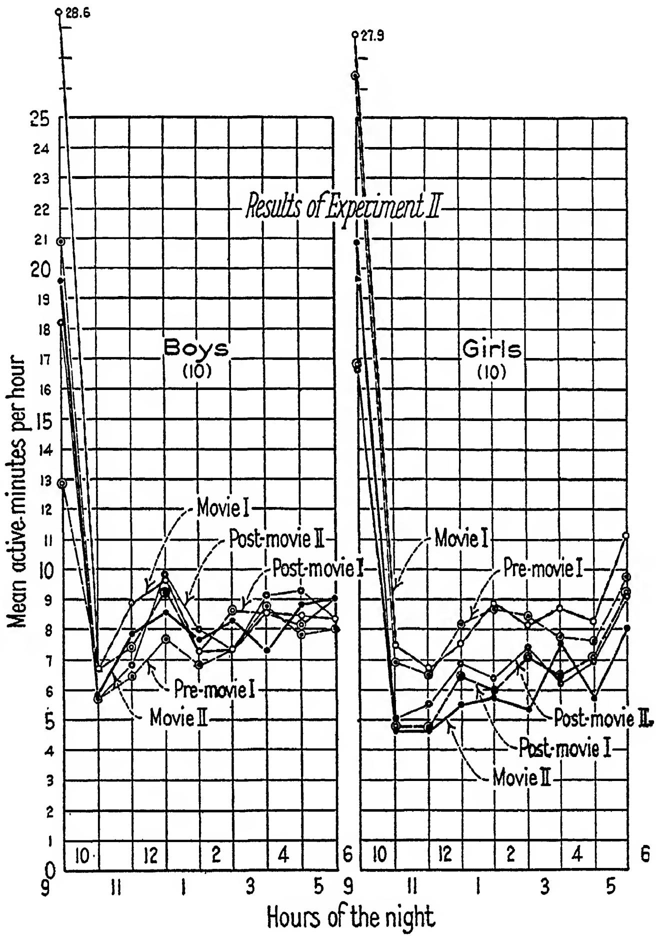

28.6
27.9
Results of Experiment II
Boys
(10)
Girls
(10)
Movie I
Post-movie II
Post-movie I
Pre-movie I
Movie II
Movie I
Pre-movie I
Post-movie II
Post-movie I
Movie II
Mean active minutes per hour
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
10
12
2
4
6
10
12
2
4
6
9
11
1
3
5
9
11
1
3
5
Hours of the night

FIG. 21

The general plan followed was to divide the children into two groups, called A and B. Group A were the occupants of beds 1 to 5, and group B, beds 6 to 10. Thus half of all the children could be used as a control group against the other half, and this condition reversed according to the plan following. The A group was taken to a show, while the B's remained at home. Both groups were at home the following night, then the B group was taken to the movie alone. This was followed by two attendances of the A group alone, and this then followed by the B group alone; after which both groups remained at home under normal sleep for one night, then the cycle was repeated with three movies for each group, then four for each, and finally five for each group. In this series there were six nights when both groups attended the same show. It was our thought that by such means we could get a critical comparison of half the group under the movie influence against the other half sleeping normally.

Tables 27 to 30 inclusive present the results of this experiment. The methodological principle involved proved unsound for several reasons. In the first place the inter-movie nights showed practically as much alteration as the movie nights themselves. Secondly, it was impossible to compare the same group of children seeing different movies, since the particular impression effect of any movie cannot be assumed to be equal to that of any other. This fact will be shown in considerable detail in the treatment of Experiments VI and VII following. From this experiment we learned many valuable lessons about method. The cumulative effects did not put in appearance, thus indicating what was shown in Experiment II, namely that the effects of separate movies may add algebraically and thus in some cases cancel or mask each other. Whereas in Experiment II

TABLE 27

RESULTS OF EXPERIMENT III BY HOURS

Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Boys, Groups A and B [3]

Hours of the Night	Group A						Group B					
	Pre-Movie	Movie Alone	Inter-Movie	Post-Movie	Movie with B	Com-bined Movie	Pre-Movie	Movie Alone	Inter-Movie	Post-Movie	Movie with A	Com-bined Movie
9	11.1	17.5	14.4	15.1	16.4	17.0	8.4	10.9	11.1	12.1	11.7	11.3
10	4.1	6.0	4.6	4.8	4.4	5.2	3.5	4.4	4.5	6.0	4.5	4.5
11	6.3	5.3	5.0	6.7	4.6	5.0	5.5	4.4	4.9	7.3	5.2	4.8
12	6.7	10.1	8.4	8.2	7.9	9.0	6.4	8.6	10.4	7.6	8.4	8.5
1	6.4	6.5	7.3	7.3	6.7	6.6	4.4	6.4	4.2	6.9	7.4	6.9
2	7.2	7.8	7.3	7.5	5.9	6.9	5.5	4.8	4.7	7.7	7.7	6.3
3	8.1	7.7	8.3	7.4	7.9	7.8	5.8	6.0	5.6	7.2	6.7	6.4
4	9.4	6.1	7.5	8.1	9.9	8.0	5.8	5.9	7.3	7.6	6.3	6.1
5	10.4	8.9	10.8	9.9	9.1	9.0	7.9	4.9	7.4	8.6	8.5	6.7
Totals	69.7	75.9	73.6	75.0	72.8	74.5	53.2	56.3	60.1	71.0	66.4	61.5
Means	7.7	8.4	8.2	8.3	8.1	8.3	5.9	6.3	6.7	7.9	7.4	6.8

The combined average for boys' pre-movie motility is 6.9; σ dis. = 0.59 and σ mean = 0.178.

[3] Boy No. 7 excluded from Group B data.

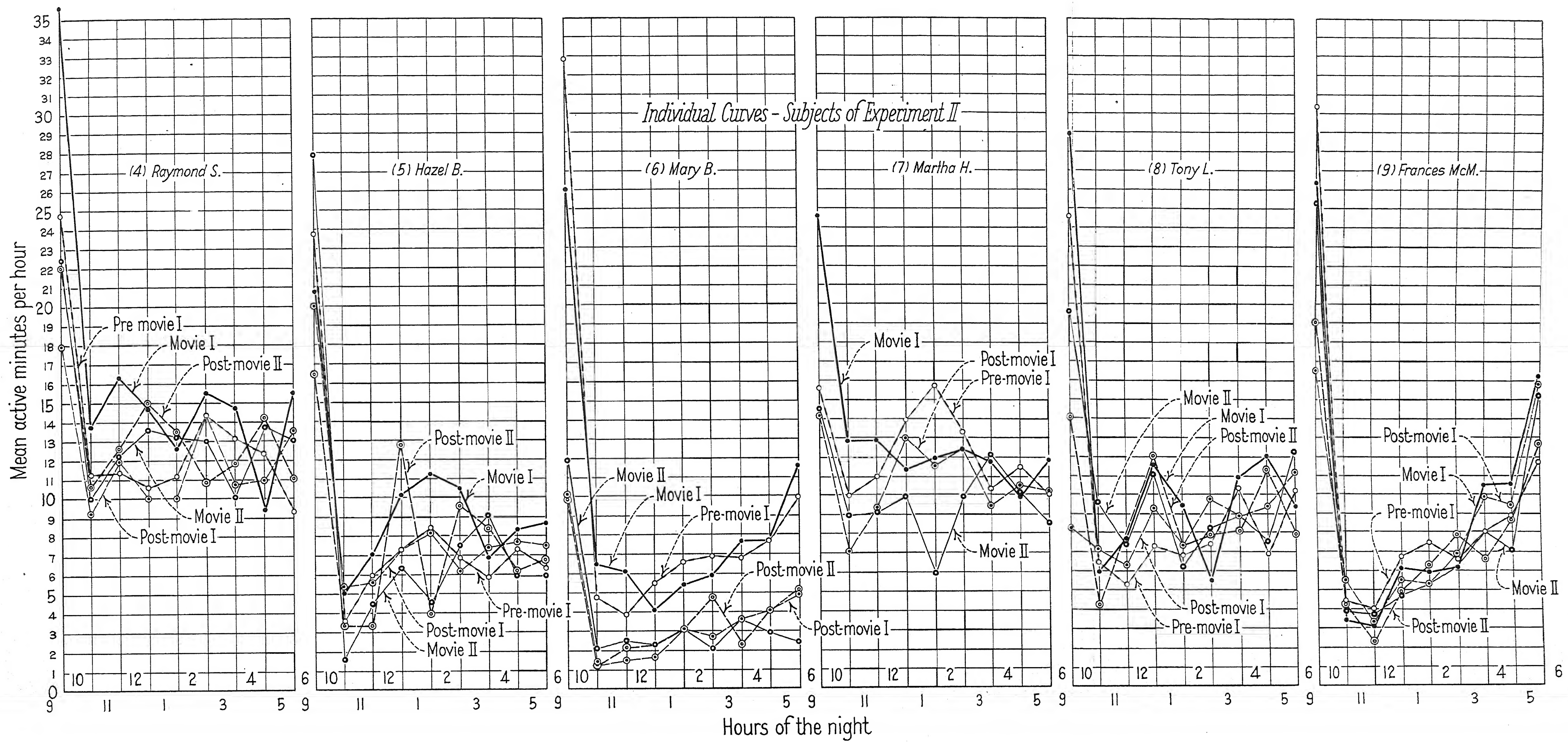
Table 28

RESULTS OF EXPERIMENT III BY HOURS

Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Girls, Groups A and B

Hours of the Night	Group A						Group B					
	Pre-Movie	Movie Alone	Inter-Movie	Post-Movie	Movie with B	Combined Movie	Pre-Movie	Movie Alone	Inter-Movie	Post-Movie	Movie with A	Combined Movie
9	12.8	15.6	16.1	14.4	14.3	15.0	13.6	19.1	15.8	14.0	14.4	16.8
10	3.8	3.3	3.4	3.5	4.1	3.7	6.3	4.6	4.4	4.2	4.3	4.5
11	5.8	5.4	4.8	4.3	5.1	5.3	4.1	5.1	5.8	4.5	5.4	5.3
12	6.1	4.8	6.3	4.4	6.2	5.5	4.4	5.8	5.6	6.5	6.7	6.3
1	6.4	5.1	5.5	5.5	6.8	6.0	5.9	6.0	5.6	6.8	6.5	6.3
2	6.4	5.7	5.8	5.6	5.4	5.6	5.7	6.1	6.3	5.6	6.3	6.2
3	6.0	5.2	5.9	5.7	5.4	5.3	5.9	6.4	5.7	6.3	6.9	6.7
4	6.4	5.8	5.5	6.3	6.2	6.1	6.7	7.8	7.0	6.7	7.1	7.5
5	6.3	5.7	6.7	7.1	5.8	5.8	8.2	8.4	6.9	6.8	8.0	8.2
Totals	60.0	56.6	60.0	56.8	59.3	58.3	60.8	69.3	63.1	61.4	65.6	67.8
Means	6.7	6.3	6.7	6.3	6.6	6.5	6.8	7.7	7.0	6.8	7.3	7.5

The combined average for girls is 6.9; σ dis. = 0.94, σ mean = 0.283.



Individual Curves - Subjects of Experiment II
(4) Raymond S.
(5) Hazel B.
(6) Mary B.
(7) Martha H.
(8) Tony L.
(9) Frances McM.
Mean active minutes per hour
Hours of the night
Pre movie I
Movie I
Post-movie II
Movie II
Post-movie I
Pre-movie I

FIG. 22

Experiment II

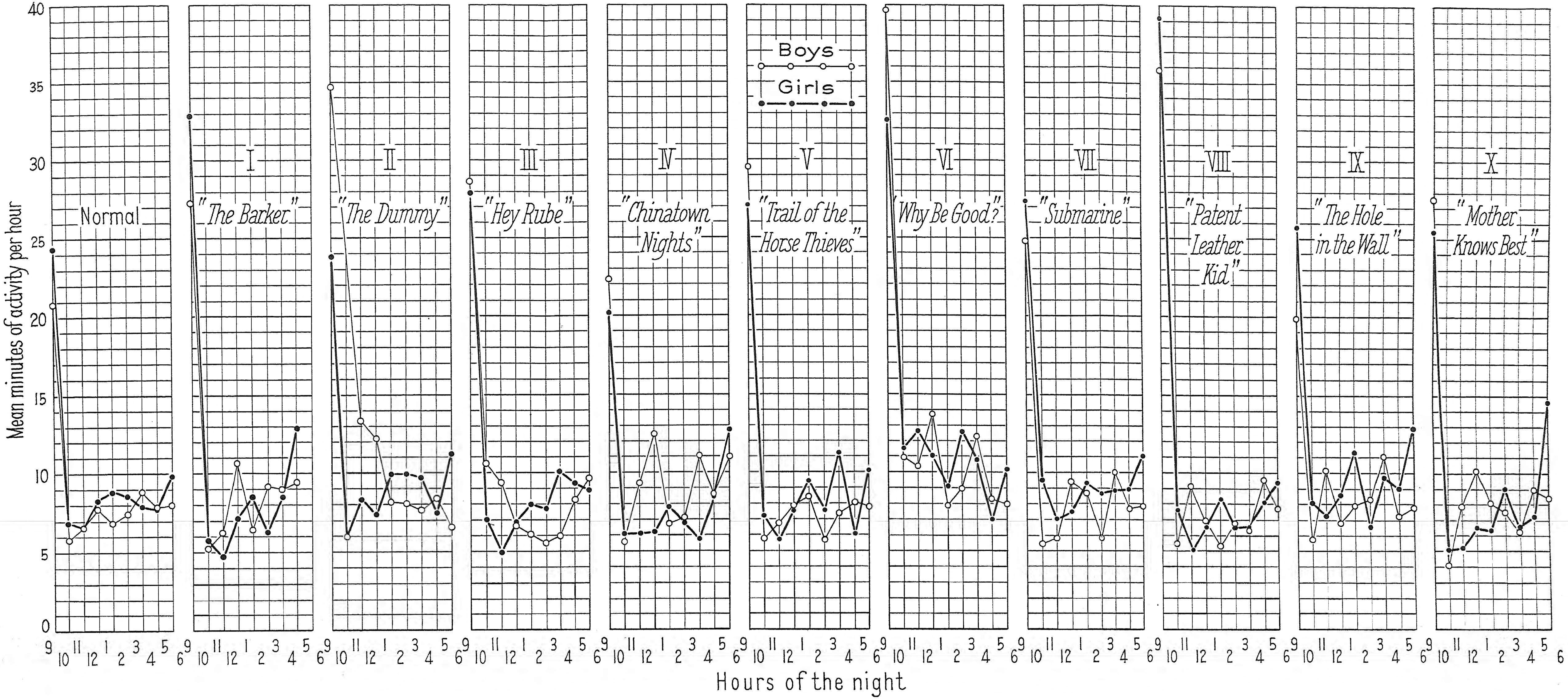


FIG. 23

TABLE 29

RESULTS OF EXPERIMENT III BY SUBJECTS

Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods; Boys, Groups A and B

Group A				Group B			
Boy No.	Pre-Movie	Movie	Post-Movie	Boy No.	Pre-Movie	Movie	Post-Movie
1	6.9		7.2	6	7.2	7.0	13.1
2	5.3	5.6	6.1	7	10.2	10.0	11.0
3	6.8	7.4	7.7	8	6.6	7.8	7.8
4	11.1	11.4	12.1	9	7.0	7.7	7.1
5	8.9	9.3	8.6	10	3.0	3.6	3.6
Totals	39.0	33.7	41.7		23.8	27.0	31.6
Means	7.8	8.4	8.3		5.9*	6.8*	7.9*

* Data for boy No. 7 omitted in computing means.

TABLE 30

RESULTS OF EXPERIMENT III BY SUBJECTS

Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods; Girls, Groups A and B

Group A				Group B			
Girl No.	Pre-Movie	Movie	Post-Movie	Girl No.	Pre-Movie	Movie	Post-Movie
1		6.7	6.7	6	5.9	5.8	5.9
2	7.2	7.8	6.3	7	6.4	8.2	7.1
3	6.6	5.7	5.9	8	10.0	7.4	6.9
4	6.1	6.0	6.6	9	5.6	9.0	7.8
5	6.7	5.7	6.2	10	5.9	6.8	6.3
Totals	26.6	31.9	31.7		33.8	37.2	34.0
Means	6.6	6.4	6.3		6.8	7.4	6.8

the children became wearied of attending the movies toward the latter part of the long series and seemed to exhibit an adaptation effect that is well known psychologically, we had expected that the plan of Experiment III would reveal the reverse of this condition, namely, a cumulative piling up of the movie effect toward the end of the series. Our expectation in this respect was not realized. It became

evident, therefore, that the best plan for succeeding experiments was to arrange the movie attendance in such a way as to parallel closely the conditions most frequently found in the average movie-going of an ordinary child.

The results for the boys of groups A and B (Tables 27 and 29) show the same sorts of increases on the average in the movies compared to the normal as were shown in the preceding experiments. The girls of group A show practically no change on the average, but those of group B show a slight increase (Tables 28 and 30), which may be accounted for by the peculiarities of the different films seen by the two groups, in addition to individual differences in the composition of the personnel of groups A and B.

Experiment IV

This experiment was limited to eleven normal nights and one movie night. It was interrupted by an epidemic which necessitated placing a quarantine on the children in the institution, and we were unable to complete the experiment for this reason. The summary of the normal sleep is shown in Table 11, page 67.

The means and standard deviations of the normal sleep motility are as follows:

	M	σ dis.	σ mean
Boys	7.7	0.57	0.180
Girls	8.2	0.935	0.292

Experiment V

This experiment consisted of thirty-five normal nights followed by five movies and ten post-movie nights. The movies seen were: "Lovin' the Ladies," "Greene Murder Case," "Around the Corner," "Framed," and "The Mounted Stranger."

Tables 31 and 32 present the summarized results of Experiment V by hours and by subjects.

TABLE 31

RESULTS OF EXPERIMENT V BY HOURS

Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys			Girls		
	Pre-Movie	Movie	Post-Movie	Pre-Movie	Movie	Post-Movie
9	18.6	28.1	19.9	22.5	26.6	18.8
10	6.0	6.5	7.8	6.3	4.5	5.3
11	6.2	7.5	7.2	6.0	4.5	6.1
12	7.1	6.1	9.1	6.7	6.1	7.2
1	6.9	6.1	7.1	6.8	6.6	6.8
2	6.1	5.6	6.1	6.8	6.8	7.4
3	6.2	7.4	7.1	7.2	7.3	7.3
4	7.0	8.2	7.3	7.7	8.0	8.2
5	10.6	10.4	7.7	10.8	8.2	9.2
Totals	74.7	85.9	79.3	80.8	78.6	76.3
Means	8.3	9.5	8.8	9.0	8.7	8.5
σ dis.	1.96			1.23		
σ mean	0.331			0.207		

TABLE 32

RESULTS OF EXPERIMENT V BY SUBJECTS

Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods; Sexes Separate

Subject No.	Boys			Girls		
	Pre-Movie	Movie	Post-Movie	Pre-Movie	Movie	Post-Movie
1	6.2	5.9	5.4	11.4	11.7	
2	10.0	9.9	9.6	6.8	6.3	5.8
3	6.3	4.4	5.3	8.9	8.6	10.5
4	11.9	12.7	12.8	7.5	7.5	7.7
5	9.0	10.8		11.5	9.4	10.0
6	8.9	9.7	10.7	8.5	8.4	7.1
7	8.3	10.7	10.9	6.6	6.4	5.7
8	9.1	11.6	9.6	11.3	12.1	11.6
9	6.4	7.3	7.2	8.5	7.9	9.5
Totals	76.1	83.0	71.5	81.0	78.3	67.9
Means	8.4	9.2	8.9	9.0	8.7	8.5

We present Tables 33, 34, 35, and 36 as a sample of the type of analysis of the pre-movie, or normal, sleep motility and that of the movie and post-movie periods. These tables

Table 33

MEANS AND SIGMAS, ACTIVE MINUTES PER HOUR, ALL PERIODS, EXPERIMENT V, BOYS

S	P	Hours of the Night																	
		9		10		11		12		1		2		3		4		5	
		M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ
1	1	19.7	15.3	3.3	2.92	2.9	*	3.4	*	4.2	*	2.6	*	3.7	*	4.1	*	8.6	6.90
	2	22.4	6.37	3.2	1.72	3.0	2.45	2.0	1.26	3.2	2.99	2.6	1.96	3.8	2.48	3.4	2.50	6.6	1.74
	3	16.6	6.10	2.6	1.91	4.0	2.32	3.9	2.07	4.1	2.51	2.9	1.64	2.8	1.33	3.8	2.40	6.2	2.75
2	1	30.1	13.5	6.2	6.81	6.7	4.39	7.0	3.28	7.4	2.94	6.3	2.48	7.8	2.24	8.7	2.62	9.7	3.38
	2	32.8	10.7	5.0	2.28	6.6	1.62	7.2	2.23	5.4	1.74	7.0	1.41	5.4	2.73	8.4	3.38	10.8	2.32
	3	24.8	6.38	5.0	1.90	6.0	3.26	8.5	2.50	7.9	3.27	5.5	2.58	8.1	2.81	10.8	4.33	9.8	3.03
3	1	10.0	9.03	6.7	4.43	6.7	4.48	7.2	6.71	5.3	3.91	4.2	3.12	4.2	*	4.5	*	6.9	4.86
	2	9.0	3.52	4.8	1.83	4.8	2.79	3.0	1.41	2.6	1.02	3.6	2.33	3.2	2.32	4.2	1.60	4.8	1.72
	3	9.5	3.58	7.2	4.69	6.8	4.19	4.4	2.60	3.8	2.32	3.6	2.94	3.3	1.55	4.5	1.63	4.1	1.45
4	1	27.3	14.4	11.3	*	9.4	5.66	8.7	5.54	8.9	5.98	8.7	*	7.3	3.17	8.7	*	12.2	7.11
	2	41.6	3.01	13.0	5.55	9.6	5.16	5.8	2.99	6.8	1.17	5.4	3.20	10.8	6.11	10.6	4.22	7.8	2.32
	3	28.7	13.2	11.8	8.27	6.3	2.15	11.1	9.02	7.8	4.28	9.3	5.29	10.0	2.83	7.7	2.41	10.1	1.97

	1	16.7	10.9	4.9	*	3.1	*	4.7	*	6.7	4.25	6.3	3.68	6.2	3.11	9.1	4.08	24.2	*
5	2	31.0	7.81	4.0	1.22	2.2	1.79	4.5	1.66	7.0	1.22	6.0	2.74	11.2	7.60	10.0	5.52	20.5	11.1
	3																		
	1	16.2	10.7	6.6	8.22	5.7	3.15	8.8	4.30	7.6	3.71	8.0	4.67	8.4	3.55	7.7	4.38	10.6	5.54
6	2	23.0	6.81	6.8	5.71	8.0	3.90	7.8	4.17	7.4	2.42	5.2	3.19	7.8	2.79	8.4	4.80	12.2	4.17
	3	18.6	8.59	10.7	6.60	9.1	9.24	8.6	2.37	11.6	3.29	10.4	5.92	8.3	2.57	9.5	2.73	9.2	3.12
	1	17.5	4.97	6.7	8.82	6.2	5.35	7.0	2.74	6.3	2.67	6.6	2.44	5.7	2.55	6.9	2.57	8.9	3.20
7	2	31.8	12.1	7.2	2.56	5.8	3.54	7.4	2.42	5.6	1.36	7.8	4.02	7.6	2.42	8.4	1.85	13.4	9.20
	3	26.7	11.1	10.3	8.80	8.0	5.97	11.3	4.86	6.4	2.62	6.4	3.47	10.0	4.07	8.7	1.73	9.4	3.47
	1	16.4	4.82	7.4	5.46	9.0	6.43	9.2	3.88	8.2	3.99	6.3	3.04	6.9	2.56	7.2	2.89	9.7	4.50
8	2	28.8	11.7	10.8	3.66	12.2	4.07	9.2	2.64	9.0	1.41	5.8	2.04	6.8	2.14	12.4	3.83	8.2	2.79
	3	15.5	6.18	8.9	3.88	11.2	3.68	13.5	6.97	7.5	3.58	5.3	2.19	8.0	1.90	9.1	3.30	6.9	1.76
	1	12.5	5.82	2.7	*	5.1	*	6.3	3.18	5.6	0.62	5.3	*	5.8	2.40	5.0	2.72	7.4	4.42
9	2	21.4	5.31	3.4	2.06	5.4	2.06	5.6	3.14	6.8	2.71	4.8	1.72	3.8	1.47	4.8	1.94	7.8	6.18
	3	17.4	10.8	4.2	1.99	5.7	2.37	9.5	3.47	6.8	3.34	4.8	1.66	5.5	1.36	3.7	2.10	6.7	2.37
	1																		
10	2	36.8	9.35	5.8	2.93	10.4	3.50	8.8	5.84	7.0	2.19	7.4	1.36	9.6	5.74	10.4	1.85	12.4	8.01
	3	20.6	12.8	5.7	1.19	8.9	2.88	11.8	3.06	11.0	3.29	10.5	3.26	9.7	1.73	10.0	2.97	10.4	2.46

S = Subject No.; P = Period: 1, Pre-Movie; 2, Movie; 3, Post-Movie

* Figures not obtained because of mechanical difficulty.

Table 34

MEANS AND SIGMAS, ACTIVE MINUTES PER HOUR, ALL PERIODS, EXPERIMENT V, GIRLS

S	P	Hours of the Night: 9 M	9 σ	10 M	10 σ	11 M	11 σ	12 M	12 σ	1 M	1 σ	2 M	2 σ	3 M	3 σ	4 M	4 σ	5 M	5 σ
1	1	24.8	*	8.8	5.54	8.6	2.27	9.8	3.94	10.5	3.00	8.4	3.77	9.5	2.50	8.1	2.95	13.0	4.95
	2	31.8	7.12	6.2	1.09	9.0	2.74	7.8	4.02	8.8	3.77	10.0	2.55	8.0	4.74	11.0	5.24	10.2	3.70
	3	24.0	3.56	14.0	4.08	22.0	5.72	27.3	13.2	10.3	4.69	13.7	9.46	10.3	6.55	5.7	2.49	9.3	1.89
2	1	16.0	5.41	3.2	*	5.0	2.58	6.3	3.27	5.4	*	6.5	2.57	6.1	2.80	5.7	1.99	7.4	4.14
	2	16.8	7.98	3.0	1.90	3.2	1.17	5.0	1.10	4.0	1.79	6.6	1.02	7.6	4.22	4.8	2.23	5.6	3.07
	3	14.4	5.87	4.2	2.14	4.5	3.07	4.3	2.90	5.1	3.08	5.7	2.57	4.8	1.25	4.8	2.09	4.3	0.9
3	1	16.9	9.84	5.3	2.42	5.3	2.06	5.7	2.74	6.2	3.19	8.5	3.77	8.1	3.91	11.1	4.83	12.9	5.15
	2	19.0	4.56	5.4	1.36	5.4	2.65	8.0	1.79	7.0	3.35	6.2	1.60	7.8	2.64	8.6	3.93	10.2	2.93
	3	15.0	4.84	10.0	13.7	7.4	3.50	8.5	4.20	7.6	2.37	10.0	4.58	9.0	3.35	11.7	3.41	15.1	3.75
4	1	22.6	13.3	4.4	4.14	4.6	2.31	5.1	2.12	6.2	2.41	6.0	*	5.8	*	5.6	*	8.1	3.95
	2	24.4	7.71	4.2	1.72	3.0	0.63	5.6	1.62	5.6	1.85	6.6	2.65	6.8	3.06	6.4	1.20	5.8	3.25
	3	14.4	7.21	4.9	2.88	6.2	2.86	6.6	2.91	6.2	1.94	8.4	2.37	6.3	3.23	8.8	2.27	7.0	3.83

	1	26.7	15.7	8.8	1.25	7.4	6.09	8.4	3.61	9.2	3.19	8.3	4.12	9.3	4.37	11.6	3.21	13.2	4.55
5	2	23.2	9.87	5.0	2.00	5.4	5.85	6.0	2.61	10.2	4.79	6.8	2.71	9.2	2.64	9.0	5.33	9.8	1.6
	3	19.6	10.6	4.2	2.27	8.0	3.13	11.1	5.09	10.2	3.25	9.6	4.43	8.6	2.80	8.9	5.07	11.0	3.38
	1	20.4	14.4	9.4	1.79	8.1	*	5.6	4.83	4.1	*	4.8	*	5.4	2.69	6.8	3.40	10.6	*
6	2	22.6	3.67	3.8	1.72	3.6	2.58	6.0	1.55	3.6	1.36	6.0	3.58	8.6	3.98	7.4	1.36	12.2	4.66
	3	16.3	13.1	4.0	1.79	6.3	8.19	5.6	4.10	4.3	2.24	3.8	2.64	5.8	2.27	7.0	2.57	10.8	3.49
	1	18.8	9.73	2.5	2.23	4.0	*	4.3	*	4.4	*	5.3	*	5.3	*	5.3	*	8.9	4.20
7	2	21.2	5.19	2.4	1.02	2.2	0.98	3.6	1.20	6.8	1.33	6.0	2.76	2.8	1.17	6.8	1.94	6.0	2.97
	3	12.5	4.86	3.5	2.25	2.8	1.78	5.6	3.17	5.6	2.80	5.1	1.87	4.8	1.94	5.0	3.16	6.3	2.10
	1	30.5	13.8	6.8	*	6.7	3.02	9.5	4.05	9.3	5.30	8.2	4.07	8.6	4.26	9.0	3.47	12.0	3.41
8	2	44.8	11.0	6.4	2.15	5.4	3.07	9.2	5.11	8.4	3.83	8.0	3.63	7.4	1.02	10.6	2.06	8.4	2.24
	3	28.9	12.0	7.1	2.30	9.3	3.93	10.0	2.86	9.3	4.00	6.9	4.70	13.3	7.75	8.9	2.17	10.3	2.33
	1	25.3	13.0	5.1	6.16	4.0	*	4.8	7.48	6.6	3.52	5.4	*	7.0	3.08	7.3	2.67	10.4	6.07
9	2	24.4	7.71	3.8	1.47	3.6	1.50	3.8	2.48	4.8	2.71	4.8	1.94	8.0	1.67	7.6	3.26	9.8	3.06
	3	29.3	16.4	4.5	2.87	4.3	2.69	5.6	3.50	6.3	3.16	9.1	5.24	5.8	3.46	10.2	3.97	10.1	7.33
10	1	15.3	5.49	4.5	*	7.5	6.73	5.5	*	10.0	3.81	10.0	3.08	13.0	4.42	7.5	4.15	7.0	*

S = Subject No.; P = Period: 1, Pre-Movie; 2, Movie; 3, Post-Movie.

* Figures not obtained because of mechanical difficulty.

TABLE 35

MEANS AND SIGMAS, LENGTH OF QUIET PERIODS, PRE-MOVIE, MOVIE, AND POST-MOVIE, EXPERIMENT V, INDIVIDUAL BOYS

S	P	Hours of the Night																	
		9		10		11		12		1		2		3		4		5	
		M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ
1	1	8.8	14.0	19.1	15.0	20.2	16.1	18.9	14.4	14.1	13.7	17.9	16.6	15.0	11.5	15.2	15.0	12.6	14.2
	2	6.5	10.1	17.6	12.8	22.9	17.7	20.7	13.9	14.5	15.1	19.1	17.1	16.5	14.5	16.6	17.0	10.1	9.5
	3	9.9	13.5	17.9	16.1	14.4	13.2	15.8	14.7	15.4	11.9	19.7	16.2	18.4	14.5	16.4	14.4	*	*
2	1	3.9	5.2	12.0	11.5	10.1	10.3	9.5	8.6	8.0	8.3	9.2	9.1	7.2	7.6	7.0	6.4	6.8	6.2
	2	2.8	2.7	10.2	9.0	9.5	6.9	8.0	9.5	10.7	11.2	7.6	6.4	11.4	11.5	6.3	6.0	5.2	4.4
	3	4.2	4.7	11.0	9.5	10.1	8.6	8.7	9.2	6.9	5.3	10.3	9.7	6.7	6.0	5.8	6.7	6.3	7.1
3	1	10.7	13.7	9.1	10.6	8.7	9.5	10.0	10.8	11.8	11.4	13.0	11.5	13.4	11.3	15.3	12.9	10.9	11.3
	2	15.0	17.0	10.2	10.0	12.4	10.0	16.7	14.3	17.4	11.1	15.7	12.7	21.8	16.2	12.7	9.0	14.7	9.4
	3	10.0	3.8	8.2	10.0	8.2	8.7	13.5	13.2	12.7	12.1	14.8	13.1	16.4	12.1	13.2	10.0	15.0	14.8
4	1	3.9	5.1	7.3	7.7	8.9	8.5	9.0	9.4	9.2	10.7	8.3	8.1	9.0	8.7	7.7	7.6	6.6	6.6
	2	2.2	1.4	7.6	8.1	6.9	7.7	12.3	12.0	9.0	7.7	13.0	12.5	8.6	7.2	7.9	7.2	9.8	9.2
	3	4.7	6.3	8.0	8.5	10.6	10.7	8.1	6.5	8.4	8.0	8.6	8.2	7.1	6.3	9.6	8.7	7.1	6.2

5	1	8.5	12.7	14.8	12.8	17.0	14.1	12.9	10.5	9.8	10.1	9.2	9.8	8.8	9.5	7.1	7.1	4.6	6.1
	2	6.1	9.2	13.2	10.9	23.1	17.0	11.7	11.3	9.7	7.7	10.3	10.4	7.5	9.4	10.5	8.1	5.5	6.9
	3																		
6	1	8.8	10.1	10.4	9.2	11.6	11.6	8.0	8.4	9.0	9.9	8.6	10.1	7.6	7.7	8.8	10.0	7.2	7.7
	2	6.2	6.8	11.1	12.4	11.3	11.6	8.7	8.5	8.2	8.9	11.4	12.7	8.6	8.4	6.4	8.8	5.7	6.8
	3	7.3	8.4	6.6	7.2	*	*	9.2	7.9	6.5	7.5	7.5	8.5	7.7	7.7	7.5	6.6	7.8	8.1
7	1	7.2	9.5	11.7	10.9	11.2	11.2	8.9	9.0	10.2	10.0	9.3	8.1	11.2	10.2	8.6	7.3	7.9	7.7
	2	5.4	5.9	10.1	8.3	11.2	12.7	7.7	8.8	10.6	10.2	9.3	9.7	8.6	8.6	7.4	8.5	6.6	6.2
	3	5.5	8.2	7.8	7.7	9.4	11.0	6.9	7.3	9.4	10.9	10.3	9.6	6.8	6.8	7.6	7.2	6.7	7.7
8	1	7.6	9.8	9.0	8.0	8.1	8.1	7.3	8.0	7.9	8.8	10.0	11.9	8.7	9.2	8.6	8.0	6.9	7.6
	2	5.8	8.6	6.8	6.3	6.4	9.1	7.7	8.4	6.0	6.9	9.3	10.0	7.5	7.7	5.0	4.0	7.6	9.5
	3	7.6	8.5	7.1	6.9	6.7	7.3	5.8	7.2	8.4	8.3	10.5	7.4	7.5	6.0	7.0	6.1	9.6	10.3
9	1	8.5	11.2	17.0	14.7	11.0	10.9	9.4	9.2	10.5	10.6	11.2	11.6	10.1	10.1	11.3	10.9	9.9	11.2
	2	6.2	8.4	17.6	13.4	10.8	9.8	10.5	10.2	8.2	7.3	10.1	9.2	14.7	9.5	10.6	9.7	10.7	11.0
	3	7.3	12.4	11.6	11 7	10.3	10.6	7.0	5.7	8.2	7.4	11.2	10.7	10.3	6.6	14.8	12.8	9.9	8.4
10	1																		
	2	4.3	5.0	12.9	13.6	8.0	5.8	7.5	6.5	9.0	9.5	8.0	6.6	7.4	7.5	6.4	6.0	8.0	7.1
	3	5.2	6.8	11.3	9.3	8.8	7.5	6.4	5.4	6.7	5.5	6.6	5.0	7.0	5.1	7.7	6.9	6.6	5.7

S = Subject No.; P = Period: 1, Pre-Movie; 2, Movie; 3, Post-Movie.

* Figures not obtained because of mechanical difficulty.

Table 36

MEANS AND SIGMAS, LENGTH OF QUIET PERIODS, PRE-MOVIE, MOVIE, AND POST-MOVIE, EXPERIMENT V, INDIVIDUAL GIRLS

S	P	Hours of the Night																	
		9		10		11		12		1		2		3		4		5	
		M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ	M	σ
1	1	8.0	8.8	7.9	7.9	8.0	7.3	8.2	8.1	6.6	6.9	9.0	8.6	7.6	7.1	7.8	7.8	6.2	6.6
1	2	3.8	4.7	10.2	7.5	7.6	5.2	7.2	6.5	7.6	7.0	7.7	6.7	8.3	9.4	5.9	9.3	5.8	5.7
	3	5.7	7.2	*	*	*	*	7.0	7.8	13.6	16.0	9.9	12.9	11.5	14.6	23.3	22.3	9.4	7.4
	1	11.2	14.9	14.8	13.8	11.6	10.0	9.6	9.2	10.9	11.8	9.0	7.7	9.8	9.2	9.6	9.4	7.6	6.8
2	2	9.0	14.6	17.8	18.1	14.2	11.4	12.0	10.0	13.3	12.3	8.1	6.4	7.9	7.2	12.0	10.0	8.1	7.6
	3	12.7	15.6	12.7	11.2	12.6	11.2	13.0	12.4	11.0	11.5	10.0	4.0	11.0	9.3	11.3	10.5	12.3	9.3
	1	7.5	9.1	10.5	10.7	10.2	9.1	11.0	11.3	10.4	11.1	8.5	8.4	8.7	9.3	6.6	6.3	5.6	6.5
3	2	4.7	6.2	9.8	9.3	10.1	11.7	7.6	6.6	9.1	11.1	9.6	8.3	9.0	10.7	7.0	7.3	4.7	3.5
	3	5.8	7.1	9.4	11.5	8.1	7.4	8.2	8.7	7.7	7.7	7.1	7.0	7.6	9.5	5.7	5.7	4.6	4.6
	1	6.4	10.1	15.1	13.1	12.7	10.4	11.7	9.5	10.5	9.0	10.7	8.9	10.6	9.1	10.4	7.8	8.3	7.3
4	2	5.7	9.4	14.7	11.1	21.9	10.4	11.8	8.2	13.0	9.9	10.2	7.6	9.5	8.8	9.2	6.6	8.1	6.3
	3	8.1	12.5	12.8	12.4	11.2	9.4	10.1	7.7	10.8	9.5	7.1	6.8	10.7	10.8	6.9	5.2	8.2	8.9

	1	6.6	8.3	12.2	12.7	10.7	11.2	8.5	9.4	8.1	8.9	8.2	9.9	8.0	9.0	6.5	6.9	6.0	7.3
5	2	5.1	6.4	13.1	11.8	13.6	17.8	11.7	11.0	6.7	9.6	9.5	10.9	8.7	6.0	9.4	9.0	6.0	7.2
	3	9.4	11.4	13.3	15.9	9.1	10.8	7.1	10.3	8.4	8.6	6.8	9.1	9.4	10.2	8.1	10.4	5.6	6.4
	1	8.1	10.4	12.3	14.4	11.5	11.9	10.9	12.5	13.8	11.3	11.3	12.4	10.0	9.1	9.3	10.6	6.2	7.1
6	2	6.5	7.3	12.8	10.8	12.3	12.6	9.3	9.5	16.6	12.4	8.4	8.3	7.1	9.5	7.7	8.1	3.8	4.5
	3	10.4	9.7	12.4	10.2	11.4	12.5	10.5	10.8	11.6	12.8	13.4	14.9	8.9	8.0	8.4	9.7	5.3	5.5
	1	11.3	15.3	20.5	15.7	14.3	13.4	14.7	13.9	12.4	13.7	12.1	13.5	11.6	12.5	11.3	11.1	8.6	8.1
7	2	19.4	17.1	20.6	13.5	26.3	14.9	14.1	14.3	10.6	10.5	10.8	11.3	19.1	20.0	9.9	9.2	10.9	9.0
	3	15.3	16.9	15.7	15.0	16.8	14.0	12.1	12.2	11.1	10.8	10.8	9.2	12.3	11.9	11.9	12.9	9.2	6.3
	1	6.8	9.6	10.1	10.5	11.1	11.3	7.7	9.0	7.3	8.9	8.1	10.2	7.4	8.7	7.4	7.5	5.6	5.8
8	2	3.4	4.6	11.2	12.4	11.9	12.7	7.5	9.0	9.2	10.0	7.6	8.3	9.1	8.9	5.9	4.4	7.4	6.3
	3	6.5	10.4	8.4	9.4	8.0	9.5	6.0	7.5	7.2	7.5	10.2	8.7	5.1	4.7	7.7	9.2	5.3	6.2
	1	5.6	8.4	12.3	12.8	13.9	13.0	11.3	10.9	8.6	9.1	10.3	11.5	8.4	8.7	7.7	7.6	6.6	7.5
9	2	4.0	6.4	15.6	11.7	14.8	11.4	17.6	14.6	15.2	12.9	12.0	10.5	6.8	5.2	8.2	8.9	6.1	6.4
	3	5.3	8.6	12.3	11.6	13.0	13.4	11.8	12.4	9.1	10.6	6.7	7.9	9.8	11.1	5.7	5.8	6.7	7.7
10	1	6.6	6.5	11.7	11.6	11.0	11.7	9.9	9.0	7.1	6.3	8.3	5.7	6.1	5.5	10.5	12.1	9.7	9.7

S = Subject No.; P = Period: 1, Pre-Movie; 2, Movie; 3, Post-Movie.

* Figures not obtained because of mechanical difficulty.

give the means and standard deviations of the distributions by individuals and by hours of the night, both for boys and girls, of activity and of quiet periods. Analyses were also made, by the use of Hollerith sorting and tabulating machines, of the number of active periods, the mean length of each period of activity, the variances (sigma squared) of each measure, etc.—in a word, about a dozen such measures were computed. It is impossible to include all these analyses. The four tables show results for the two most significant variables. We present them in order that any interested person may make detailed examinations to satisfy himself regarding this experiment as one typical of all the series.

As an illustration of the method of examining the difference between the mean values of the average active minutes per hour on movie nights and those of normal nights, we may note the following figures:

	Boys			Girls		
	Mean	σ dis.	σ M	Mean	σ dis.	σ M
Normal	8.30	1.96	0.62	8.9	1.23	0.389
Movie	9.54	2.64	0.83	8.7	3.20	1.012
Diff.	1.24			0.2		
σ diff.	0.3275			1.3294		
$\frac{\text{Diff.}}{\sigma\ \text{diff.}}$	3.786			0.015		

Here the change in the boys' average in the movie sleep is a difference of 1.24 active minutes per hour, and the standard deviation increases from 1.96 to 2.64. This difference is an increase of 15 per cent of the 8.3 minutes activity per hour under normal conditions. This may seem a small amount but actually it is quite large in view of the change in the standard deviations. The critical ratio is 3.78. This is the ratio of the difference in the means to the standard error

of this difference. If we now consult an appropriate table of the probability of such a change occurring by chance, we find that there is less than one chance in 200 that such would be the case. Or we may express the same idea by saying that there are 99.5+ chances in 100 that this difference is a true and significant difference.

If now we examine the girls' records, we note that the movie shows a slight decrease in the group mean; but with a larger change in the standard deviations than we observed in the case of the boys. The standard error of the difference in the means is 1.32, or about 6.5 times the difference itself! This yields a critical ratio that indicates that *as a group* these girls showed no significant change in mean hourly motility after the movies as compared to the normal.

These comparisons relate only to this one experiment, No. V. One may ask: "Well, why do you not present similar calculations for all of the experiments in which movie sleep was compared with the normal?" Our reply is that we do not believe the result would give a true enough picture to justify the labor of computation, for the reason that a careful study of the figures and graphs indicates that (1) there is a carry-over of the influence of one movie to another where these are seen on successive nights; (2) *within the group* there are those whose large increases are negated by others having large decreases. This makes *group* averaging a poor representation of the true situation. We are convinced, partly on these grounds, and partly on theoretical ones, that the movie influence is a highly individual affair, and that each child presents a problem such that we can only study *how he differs from himself* when we look at him under the normal and the experimentally varied conditions. True, we can still sum or pool these net individual changes for examination. This we have done.

Experiment VI

This experiment followed the same general bracketing plan utilized in the other movie experiments; that is there was a period of fourteen normal nights, and the movie series was followed by eight normal nights. The children were taken to six movies during a period of two weeks. This was done in order to approximate the distribution and frequency of attendance shown by many average children. The movies were "Movietone Follies of 1930," "Rough Romance," "Strictly Unconventional," "Concentration Kid," "This Mad World," and "Wild Company."

Tables 37 and 38 present the data by subjects and by hours of the night.

Figure 24 is presented here as a representative sample of the influence of the arbitrary temporal unit selected in plotting the motility data upon the general shape of the curves. The bottom part of the figure shows the comparison

TABLE 37

RESULTS OF EXPERIMENT VI BY HOURS

Movie; Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys				Girls			
	Pre-Movie	Movie	Inter-Movie	Post-Movie	Pre-Movie	Movie	Inter-Movie	Post-Movie
9	15.4	20.4	16.4	16.2	10.8	10.5	10.8	10.1
10	5.7	4.5	6.0	6.2	4.9	3.8	4.7	4.6
11	5.9	5.3	6.4	7.2	4.1	4.8	4.6	5.4
12	7.4	6.1	6.4	7.6	5.6	4.6	4.7	6.6
1	7.7	6.2	7.1	7.8	6.0	5.4	5.1	6.6
2	7.3	8.1	7.7	6.6	5.8	6.0	5.9	6.1
3	8.0	6.7	7.3	7.6	6.5	6.2	6.4	6.7
4	7.3	7.3	8.2	8.0	6.8	6.2	6.2	7.6
5	15.7	15.8	15.1	12.2	15.9	16.0	23.4	16.8
Totals	80.4	80.4	80.6	79.4	66.4	63.5	71.8	70.5
Means	8.9	8.9	9.0	8.8	7.4	7.1	8.0	7.8

TABLE 38

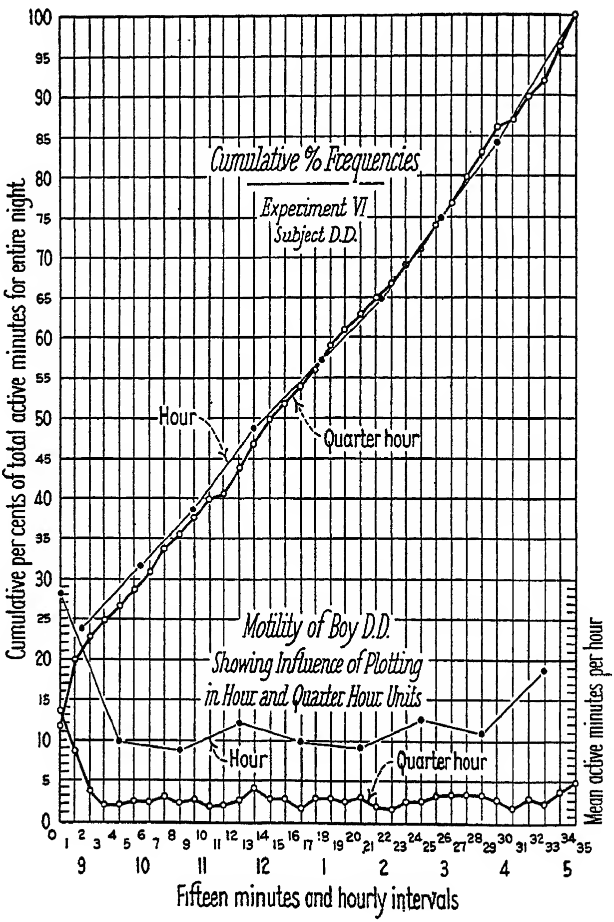
RESULTS OF EXPERIMENT VI BY SUBJECTS

Movie; Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods; Sexes Separate

Subject No.	Boys			Girls		
	Pre-Movie	Movie	Post-Movie	Pre-Movie	Movie	Post-Movie
1	8.9	8.8	9.6	6.5	5.2	6.7
2	6.5	5.6	6.9	3.6	3.9	5.4
3	6.4	6.1	6.4	5.3	4.9	5.4
4	9.4	8.0	7.9	6.8	6.9	7.0
5	10.9	11.7	10.2	6.5	5.9	7.0
6	13.4	14.5	11.4	8.8	9.4	8.9
7	12.2	11.1	12.9	8.8	7.4	9.1
8	6.5	8.0	6.4	7.6	7.2	8.4
9	6.5	6.7	7.1	11.1	11.4	12.1
10	8.8	9.0	9.4	8.4	8.4	8.4
Totals	89.5	89.5	88.2	73.4	68.6	78.4
Means	9.0	9.0	8.8	7.3	6.9	7.8

of the same data plotted in hour and quarter-hour units. The two horizontal lines represent the cumulative per cent frequencies of active minutes in class intervals of hours and quarter-hours. Note that if the bottom (quarter-hour) curve is raised sufficiently, it will fit quite closely the general shape of the hour curve above it, and that the two cumulative curves show essentially no difference. We may conclude from the examination of about 40 similar curves on individual subjects that the distribution of motility within any hour does not differ significantly from the distribution within any quarter-hour and that no serious distortion in the curves is introduced by the selection of too large a temporal unit as a class interval in plotting the motility data.

As a sample of the detailed hourly analysis of the pre-movie, and post-movie data, we present the following tables (38a, 38b, and 38c) to show how the data were assembled in each of the experiments.



Cumulative % Frequencies
Experiment VI
Subject D.D.
Motility of Boy D.D.
Showing Influence of Plotting in Hour and Quarter Hour Units
Hour
Quarter hour
Hour
Quarter hour
Cumulative per cents of total active minutes for entire night
Mean active minutes per hour
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
9 10 11 12 1 2 3 4 5
Fifteen minutes and hourly intervals

FIG. 24

TABLE 38A

SUMMARY SHEET, PRE-MOVIE

Mean Active Minutes per Hour, Experiment VI

Subject	Age	Boys								
		Hours of the Night								
		9	10	11	12	1	2	3	4	5
1	9^6	16.9	4.5	4.6	4.4	5.0	6.7	7.7	7.2	21.9
2	8^5	9.9	6.4	5.1	4.7	4.8	5.4	4.6	6.6	10.7
3	10^8	7.8	4.1	6.2	5.3	5.3	5.6	5.7	5.7	12.1
4	9^8	9.9	6.7	6.9	8.4	11.1	7.0	11.2	7.9	15.9
5	12^8	21.7	3.4	5.6	8.6	6.4	9.9	10.1	8.8	23.6
6	13^4	28.3	9.8	8.7	12.1	9.8	9.1	12.7	11.0	18.7
7	13^0	20.3	10.2	8.6	11.3	11.7	12.2	10.4	8.6	16.2
8	11^{11}	15.9	2.3	3.7	5.1	5.0	5.7	5.8	5.9	9.1
9	8^1	13.4	2.2	1.9	4.6	6.6	2.8	4.6	5.5	16.7
10	17^2	9.6	7.0	8.1	9.8	10.9	8.4	7.1	5.5	12.1
Mean		15.4	5.7	5.9	7.4	7.7	7.3	8.0	7.3	15.7
σ dis.		6.37	2.64	2.20	2.86	2.60	2.67	2.87	1.84	4.35
		Girls								
1	7^9	9.4	3.8	4.2	7.2	4.8	3.9	4.8	4.5	16.1
2	8^8	6.5	0.6	2.0	2.5	3.5	3.3	3.9	2.9	7.1
3	7^8	5.8	4.9	3.5	2.5	4.5	4.5	4.6	3.5	14.1
4	10^1	8.5	5.0	4.9	4.3	4.2	5.7	6.9	5.9	16.3
5	10^5	8.5	5.2	3.5	4.5	5.0	5.4	7.5	6.3	12.8
6	16^{10}	12.4	6.6	3.6	7.3	6.5	5.3	7.8	10.1	19.5
7	14^2	18.8	4.2	4.2	6.2	6.5	6.7	6.3	7.8	18.4
8	15^7	10.0	5.5	4.7	6.5	6.4	6.0	6.5	6.5	16.2
9	15^5	10.3	6.3	6.9	10.5	12.7	12.2	8.8	12.6	19.8
10	12^0	17.7	6.5	3.4	4.8	6.2	5.2	7.5	7.7	18.5
Mean		10.8	4.9	4.1	5.6	6.0	5.8	6.5	6.8	15.9
σ dis.		4.07	1.74	1.01	2.35	2.37	2.41	1.53	2.89	3.00

A detailed analysis of the response of each child to each of the six motion pictures of this experiment is presented below (Fig. 25). In explanation of the figure we should call attention to the following statistical devices used in presenting the data. The ordinates at the left represent the range of percentages of increase and decrease in motility which are derived from the ratio of the means under the movie condition to those of the normal period. Each child

TABLE 38B

SUMMARY SHEET, MOVIE

Mean Active Minutes per Hour, Experiment VI

Subject	Age	Boys								
		Hours of the Night								
		9	10	11	12	1	2	3	4	5
1	9^{6}	11.0	6.0	5.8	5.7	8.0	7.2	6.8	7.0	22.0
2	8^{5}	7.3	4.2	3.4	4.3	4.0	5.8	5.0	4.8	11.2
3	10^{8}	9.2	2.8	4.2	3.5	5.3	5.3	4.5	6.0	14.2
4	9^{8}	10.9	3.3	3.2	5.8	5.5	11.7	7.5	8.0	16.2
5	12^{8}	38.0	5.0	4.3	5.2	9.7	10.8	7.5	8.8	16.2
6	13^{4}	37.0	8.3	10.2	10.2	8.7	12.2	12.0	11.7	19.8
7	13^{0}	26.8	6.7	8.8	9.0	6.8	7.5	9.0	8.5	16.7
8	11^{11}	25.3	2.0	2.3	7.0	4.2	7.2	5.8	7.8	10.8
9	8^{1}	17.5	3.2	3.5	3.8	4.0	3.7	3.3	4.2	17.3
10	17^{2}	21.5	4.0	7.3	6.5	5.8	10.0	6.0	6.3	14.0
Mean		20.4	4.5	5.3	6.1	6.2	8.1	6.7	7.3	15.8
σ dis.		10.74	1.84	2.46	2.23	1.77	2.79	2.45	1.97	3.34
		Girls								
1	7^{9}	7.8	3.8	3.4	2.8	2.8	4.0	3.8	5.8	12.2
2	8^{8}	8.6	0.6	2.0	2.2	3.2	2.8	1.2	3.0	11.8
3	7^{8}	5.5	3.8	4.3	3.7	3.2	3.5	3.8	3.5	12.7
4	10^{1}	8.2	3.2	4.6	3.4	4.0	7.6	5.4	3.8	21.8
5	10^{5}	9.8	2.8	3.5	3.2	5.5	4.7	4.2	4.7	14.7
6	16^{10}	13.2	5.0	5.7	6.3	6.2	7.5	10.5	8.2	22.0
7	14^{2}	11.8	3.8	5.2	5.8	7.2	7.7	5.8	4.8	14.3
8	15^{7}	11.7	5.2	5.0	4.3	4.8	4.8	5.8	8.2	15.3
9	15^{5}	13.3	6.2	10.2	9.7	10.3	10.3	11.8	10.8	19.5
10	12^{0}	15.0	3.8	4.0	4.8	6.8	6.7	9.3	9.5	15.7
Mean		10.5	3.8	4.8	4.6	5.4	6.0	6.2	6.2	16.0
σ dis.		2.96	1.61	2.06	2.02	2.23	2.28	3.13	2.60	4.31

is represented by a black vertical line, the height of which indicates the per cent of increase or decrease in activity in the night following his viewing this film. The horizontal intercepts on this bar indicate the standard deviation units of the individual's mean active minutes per hour for normal sleep both for the first five hours and for the entire night. The statistical principle here enables us to see at a glance the number of standard deviation units of normal sleep

The Movies of Experiment VI

(1) "Movietone Follies of 1930" (2) "Rough Romance" (3) "Strictly Unconventional" (4) "Concentration Kid"
(5) "This Mad World" (6) "Wild Company"

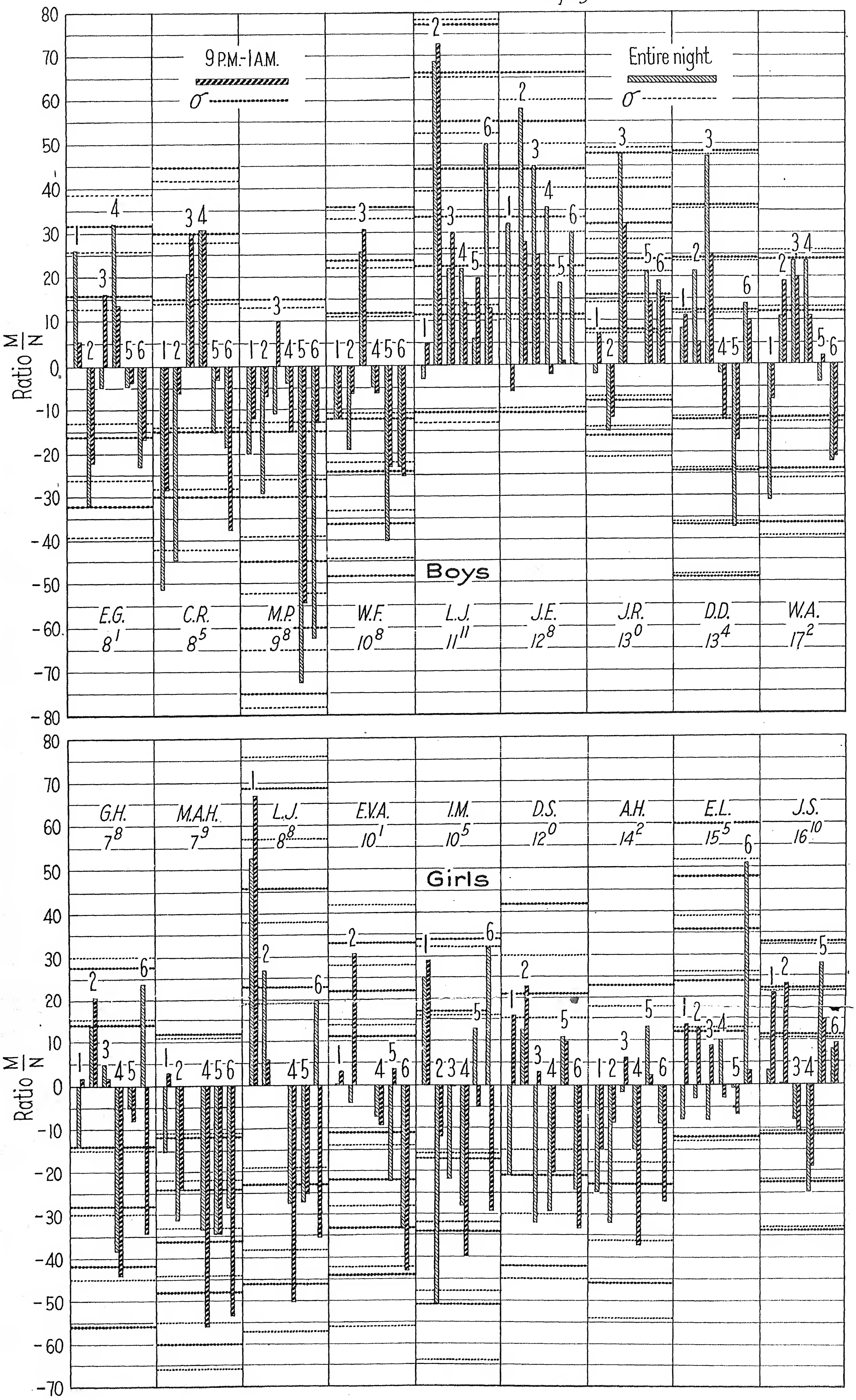


TABLE 38C

SUMMARY SHEET, POST-MOVIE

Mean Active Minutes per Hour, Experiment VI

Subject	Age	Boys								
		Hours of the Night								
		9	10	11	12	1	2	3	4	5
1	9^{6}	12.5	6.7	8.1	6.7	5.9	6.2	10.1	11.1	19.2
2	8^{5}	11.0	4.0	7.6	5.2	3.6	7.2	6.9	5.5	11.5
3	10^{8}	12.7	4.6	5.5	4.4	5.6	4.1	5.7	5.1	10.2
4	9^{8}	10.4	4.6	7.4	10.4	7.6	5.5	8.1	6.0	11.9
5	12^{8}	17.2	6.1	6.2	9.0	11.0	7.1	8.9	11.0	15.6
6	13^{4}	16.1	14.4	12.2	8.1	10.5	8.4	8.2	9.9	14.5
7	12^{0}	19.0	10.2	10.4	14.1	16.9	9.6	12.6	11.2	11.7
8	11^{11}	18.4	1.4	3.1	5.2	5.7	4.9	5.0	6.7	7.0
9	8^{1}	24.6	2.6	2.6	4.4	4.2	4.9	4.6	6.9	9.1
10	17^{2}	20.1	7.4	9.1	8.7	6.8	8.3	6.3	6.7	11.3
Mean		16.2	6.2	7.2	7.6	7.8	6.6	7.6	8.0	12.2
σ dis.		4.32	3.65	2.91	3.00	3.71	1.77	2.35	2.45	3.21
		Girls								
1	7^{9}	7.0	4.1	6.9	6.1	5.6	4.0	4.7	4.8	16.8
2	8^{8}	9.1	1.4	4.2	3.2	7.0	3.6	4.7	3.0	12.0
3	7^{8}	3.6	4.9	2.6	5.0	5.1	3.9	4.9	5.9	12.6
4	10^{1}	8.9	5.6	3.4	4.0	5.4	5.2	6.4	7.3	17.1
5	10^{5}	11.0	3.7	2.9	4.3	5.4	3.8	9.3	6.4	16.4
6	16^{10}	11.2	4.9	5.6	8.2	4.8	5.9	6.9	9.6	23.0
7	14^{2}	10.8	5.1	6.3	13.7	7.8	7.7	8.1	8.1	14.7
8	15^{7}	9.8	5.6	7.0	5.7	7.0	6.2	6.8	9.1	18.2
9	15^{5}	14.8	7.2	9.1	12.3	10.0	12.6	9.2	12.3	21.6
10	12^{0}	15.1	3.3	6.0	3.9	7.6	8.0	6.1	9.3	16.6
Mean		10.1	4.6	5.4	6.6	6.6	6.1	6.7	7.6	16.8
σ dis.		3.25	1.51	2.14	3.40	1.66	2.69	1.83	2.60	3.34

motility which is equivalent to the change incidental to the movie. Thus for boy No. 1, E.G., we note that there is an absolute increase in motility of 26 per cent following his viewing the "Movietone Follies of 1930." The normal standard deviation for the entire night was equivalent to thirteen of these scale units. Thus we may say that the "Movietone Follies" produced a change in the sleep motility of this boy equivalent to two standard deviation units

of his normal sleep for the entire night. It should be noted that the size of the standard deviation unit differs for each child, for the reason that it is a measure derived from his own normal sleep record. Some notion of the magnitude of such a change can be gained from a reference to the curve of the normal probability integral. In the probability curve an ordinate erected 0.5 sigma (standard deviation unit) to the right of the mean encloses an area which includes 19.5 per cent of the entire distribution; 1 sigma includes 34.13 per cent; 2.5 sigmas, 49.48 per cent; 3 sigmas, 49.86 per cent. It will be noted, for example, that in the case of M.P. the movie "This Mad World" was followed by a change of 5.5 sigma units. The likelihood of such a large change occurring by chance is infinitely small. We can say that a change of 1.5 sigma units is of such magnitude that the chances are 43.32/50 or 86.64 chances in 100 that it represents a true difference due to the movie; for a deviation of 3 sigmas the chances are 99.72 in 100, etc.

The figure shows that the movie influence in the case of some of these children is invariably in the *depressor* direction; that is, it always induces *less* motility in sleep; for example, M.P. In the same figure we note that in the case of L.J. and also of J.E. every movie *increases* the motility by a significant amount. In still other cases the various pictures have varying effects: some increase, some decrease.

A study of these bar diagrams gives more concrete justification of the statement pointed out previously, that the maximal influence is found in the fore part of the night. In almost every case the change is greater for the hours 9:00 to 2:00 than it is for the entire night, and we also call attention to the fact that in the great majority of the

cases where the trend is in one direction for the first half of the night, the same trend is maintained for the entire night.

It is impossible to print here all of the comparative statements which might be made from a study of Figs. 25 and 26. The reader can observe for himself the fact that each motion picture produces a highly differential effect upon the different children seeing it. This fact will be shown even more clearly by the data of Experiment VII.

Experiment VII

This experiment involved three movies, "Remote Control," "Billy the Kid," and "Just Imagine." These were seen on Monday, Wednesday, and Friday nights of the same week.

Tables 39 and 40 show the summarized data by hours and by individuals.

TABLE 39

RESULTS OF EXPERIMENT VII BY HOURS

Movie; Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys			Girls		
	Pre-Movie	Movie	Post-Movie	Pre-Movie	Movie	Post-Movie
9	14.6	16.8	22.3	9.7	15.3	9.2
10	5.3	4.4	6.1	4.0	3.3	3.8
11	6.1	5.3	6.1	4.7	3.7	5.4
12	7.1	5.6	7.1	5.7	5.6	5.2
1	7.2	6.6	7.0	5.7	5.7	5.6
2	7.7	6.3	7.9	5.7	6.1	6.0
3	7.5	7.1	7.7	6.3	4.9	6.1
4	8.3	8.9	8.2	6.9	6.2	6.9
5	10.6	13.0	12.0	15.8	20.4	14.1
Totals	73.4	74.0	84.4	64.5	71.2	62.3
Means	8.2	8.2	9.4	7.2	7.9	6.9

TABLE 40

RESULTS OF EXPERIMENT VII BY SUBJECTS

Movie; Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods; Sexes Separate

Subject No.	Boys			Girls		
	Pre-Movie	Movie	Post-Movie	Pre-Movie	Movie	Post-Movie
1	9.6	9.7	10.3	4.5	6.2	6.7*
2	6.5	6.3	7.2	7.4	7.8	7.4
3	8.9	10.6	11.2	6.3	8.8†	6.6
4	9.6	9.9	9.7	6.9	7.7	6.8
5	7.6	5.4	Disch.	10.5	11.7	9.5
6	10.1	9.5	10.5	7.6	7.6†	6.9
7	7.5	7.9	Disch.	8.0	9.6	7.5
8	5.7	4.7	4.9	6.0	7.2	6.1
9	6.3	7.4	8.0	9.0	6.4	Disch.
10	10.8	11.0	13.1	5.5	6.2	5.0
Totals	82.6	82.4	74.9	71.7	79.2	62.5
Means	8.3	8.2	9.4	7.2	7.9	6.9

* Only two nights.
† Attended only two movies.

Figure 27 presents in diagrammatic form the analysis of the effect of these three pictures on each individual child. It should be noted that these bar diagrams are arranged in order from greatest to least influence from positive through negative. As stated before, the dots interrupting the bars are the normal sigma units for the first five hours of the night for each individual child.

It may be of some interest to the reader to consider a somewhat detailed study and analysis of the film "Billy the Kid" and the effect it produced upon the twenty children of this experiment. This film is a picture of the primitive Western days and tells the story of a notorious youth who in order to avenge the murder of his father takes the law into his own hands. There is considerable gun play and rough riding, and the hero is presented in a glorified light. This is the sort of picture which would be expected to have

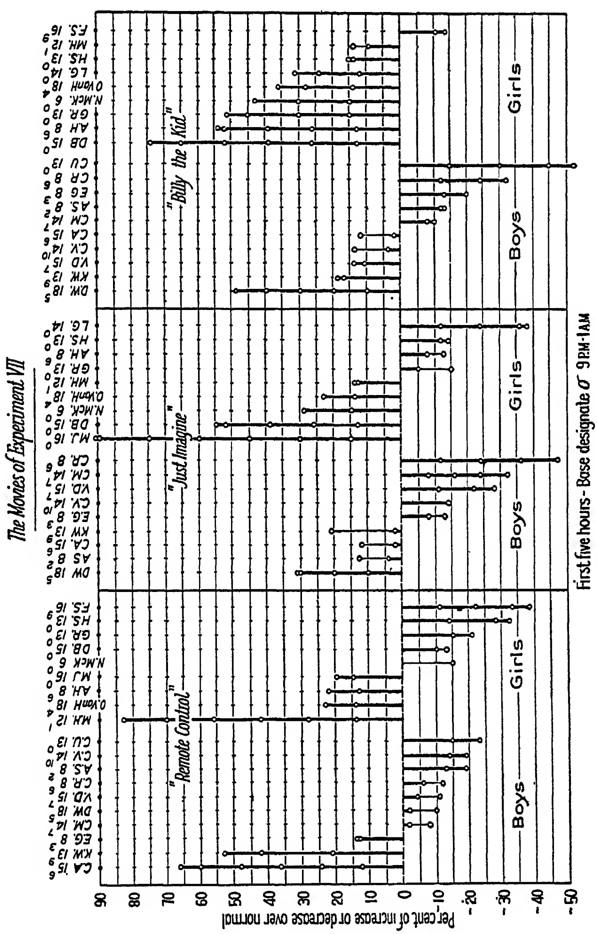

The Movies of Experiment VII
"Remote Control"
"Just Imagine"
"Billy the Kid"
Boys
Girls
Boys
Girls
Boys
Girls
Per cent of increase or decrease over normal
First five hours - Base designate σ 9 P.M.-1 A.M.

FIG. 27

a distinctive influence upon children. As we compare the individual records, we note that the most distinctive feature is the consistent change in the influence on the girls. Of the nine girls who saw this picture, six deviated two or more full sigma units *above* normal, while in the case of the boys "Billy the Kid" differed very little from either of the other two films. This figure emphasizes the fact that if we take various individual children and compare their reactions to the three pictures, we find considerable variation.

6. INTERVIEWS

DURING the mornings following movie presentation the children were interviewed by one of the experimenters.[4] Each child was encouraged to tell his own story of what he had seen and how he felt about it with a minimum of leading questions and with care taken not to force an answer or to draw out from the child answers aimed to please the interrogator.

It was found from the observations of the children and from reports from the matrons that the children generally did not talk about the movies to any great extent. A few of the older girls would tell the story of the picture to the other girls who had not attended the performance, while working in the morning, for example, while ironing.

The younger children recalled incidents during the interviews which were largely drawn from the comedies. As a rule the younger children did not get a continuity of story from the feature picture.

The preferences in an overwhelming majority of the cases were for cowboy pictures,—pictures in which there was swift action and in which a relatively small amount of the story was developed in conversation were usually preferred

[4] Mrs. Eleanor Hyde Martin, who had previously served for a year as a member of the staff of the Bureau and who therefore was not only well acquainted with the technique of winning the confidence of the children but also was familiar with the nature of the problem.

and understood better than abstract, ethical, or moral issues. The method of direct questioning was found to be very unsatisfactory. In answer to such a question as "How did you sleep last night?" the child might reply, "All right." If the same question was repeated later on, but in the form "You didn't sleep so well last night after the movie, did you?" the question would then receive the answer, "No, I couldn't get to sleep." But the further remark, "But you said you slept well last night," would receive the answer "Yes." This is indicative of the type of so-called suggestibility referred to by Stern and other psychologists which characterizes children's testimony.

Reports from the matrons indicate that no changes in the behavior of the older children are observable after they have seen the movies. It should be borne in mind that this is anecdotal or observational evidence and should be taken at its discount value.

It is the consensus of three of the investigators, who spent considerable time interviewing the children, that very little reliable evidence as to the influence of movies can be obtained from this procedure.

7. SOPHISTICATION

DOES frequency of previous attendance at the movies play an important rôle in the amount of the influence? While it is impossible for us to obtain reliable data on the frequency of attendance of these children prior to their admission to the Bureau, we may cite the two following cases as illustrative of two extremes in this respect.

1. Tony L., aged 12^3, with a mental age of 9^2 and I.Q. of 75, reported that as a newsboy a considerable portion of his earnings was spent in attending the movies, averaging four times through the week and two or three times on Sundays. This chap was able to recall in considerable detail the facts of the

stories of each picture he had seen in Experiment II. When asked to rank the pictures as to those he liked best and those he liked least, he picked as his first choice "The Patent Leather Kid," "Submarine," "Sunrise," "Thunderbolt," and "The Red Dance." The ones he liked least were "The Hole in the Wall," "Why be Good?" "The Barker," and "The Dummy."

His record shows a significant increase, actually 34 per cent, in the first five hours of the night on all pictures of all types.

2. In contrast to the first case, we cite Raymond S., aged 13^9, with a M.A. of 10^7 and I.Q. 77. This boy had seen no talking pictures prior to his admission to the Bureau. He reported that he had seen only one or two silent pictures in a small southern Ohio coal-mining town high school. Of the pictures shown in Experiment II he preferred "Trail of the Horse Thieves," "Submarine," and "The Patent Leather Kid," and was least pleased by "Mother Knows Best," "Fashions of Love," and "Red Hot Speed."

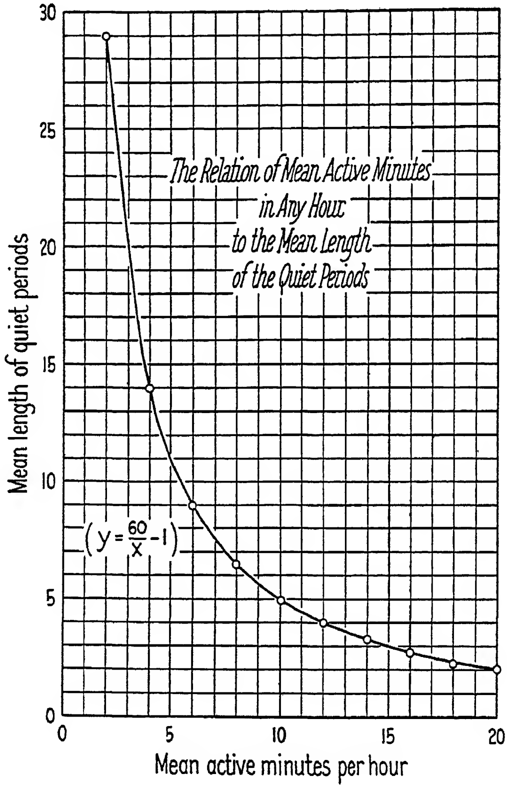
In spite of the fact that this series of talking pictures represented a novel experience for Raymond, his increased motility was practically an exact duplicate of that shown by Tony.

We do not believe that the degree of motion-picture sophistication is likely to be a very potent factor in determining the amount of influence of a given movie on the sleep motility of a particular child. It is true that our evidence is fragmentary and incomplete, but a study of the previous figures illustrates such wide variations and such lack of consistency in the effects of different pictures on children who differ widely in these respects that we are forced to conclude that sophistication is not a prominent factor. However, boys who have worked as ushers in motion-picture theaters report to us that they become "fed up" on the movies and prefer not to see more of them. Whether frequent attendance will produce the effect of greater interest or the opposite effect of "desensitization" to the movies is an interesting and important but still unsolved problem.

8. DISCUSSION OF RESULTS

How shall we interpret the various magnitudes of increase or decrease in motility following the movies? We feel obliged to call attention at this point to the fact that physiological time (79) is not necessarily clock time. We mean by this the fact referred to in Chapter I that the various organs and tissues of the body exhibit widely varying rates of anabolism and katabolism. In some cases an oxidative change may occur with great rapidity, whereas the repair, or restoration of the tissue to its normal state of irritability, is very slow. Other adjacent tissues or organs may exhibit the reverse of this process. What, then, can we say about the significance of an increase in motility amounting on the average to, let us say, 100 per cent? For illustration let us assume that a child spends 6 minutes in an hour in activity. There will then be 54 minutes of quiet, each quiet period being of 9 minutes' duration (assuming an equal distribution of the active minutes, and that one active minute comes at one end of the hour). In fact, we do not need to *assume* this distribution, since our analysis has shown that in every hour, from 10:00 P.M. to 6:00 A.M., the average active period is of about 1.25 minutes' duration. In Fig. 28 we have plotted various values of the mean number of active minutes in an hour against the mean length of the quiet periods based on this assumption. From this figure we note that if the movie influence increases the number of active minutes to 12 in the example just cited, the average length of the quiet periods will now be reduced to 4 minutes.

It will be noted from the figure that an increase of a small number of active minutes per hour has great effect upon the mean length of the quiet periods where the activity is



The Relation of Mean Active Minutes in Any Hour to the Mean Length of the Quiet Periods
$(y = \frac{60}{x} - 1)$
Mean length of quiet periods
Mean active minutes per hour
0
5
10
15
20
25
30

FIG. 28

relatively low, and this effect decreases as the number of active minutes increases. In the light of this consideration, the small movie influence on the low mean activity of the younger children may appear more significant than at first glance. A thorough examination of Table 19 will make this point clear.

Also, since the true distribution of quiet-period lengths is not of the general form of the "normal" probability curve, the effects of increased motility will be even more significant, since the very short quiet periods are in the great majority, and cutting a minute from a quiet period 2 minutes in length is probably much more significant from the standpoint of relaxation and recuperation than cutting a minute from a 30-minute period of quiet.

It will be noted that a decrease in the mean number of active minutes per hour has a greater effect in increasing the length of the quiet periods than an equal increase in the number of active minutes has in the opposite direction, starting from the same value. As we have pointed out, this graph is not based on the true distribution of lengths of quiet periods, but Figs. 9, 10, and 11 show that the greater proportion of the shortest quiet periods occur in the hours of greatest activity, namely the first and last hours of the night. Between these extremes the distribution of activity accords fairly well with the general assumption upon which Fig. 28 is based. These hours, 10:00 to 5:00, are those in which the true sleep of the night occurs. The equation of this relation (Fig. 28) may be generalized as

$$y = \frac{60}{x} - 1,$$

where y is the mean length of the quiet periods and x represents the number of active minutes in any hour. This relation we believe has great significance. It is interesting

to note that for all our children the mean number of active minutes per hour, for all hours, is about 8.7. Inspection of Fig. 28 shows that this point falls at about the point of inflection. Increases in activity beyond this have ever lessening influence on the length of the quiet periods.

It should also be noted in dealing with the problem of the significance of increased motility that the quiet periods at all hours of the night do not exert the same recuperative agency. Reference to Figs. 7 to 11 will show that the quiet periods of longest duration occur at about the second hour of the night and that these diminish progressively hour by hour until morning. Also we should like to point out that the person seeking to interpret the significance of increased motility should bear in mind that the percentage increase or decrease, in order to be significant, need not necessarily be the same for two individuals or for the same individual on different nights or for different hours of the same night. Even though the normal mean activity may be identical for two children, an increase of 25 per cent does not necessarily justify the interpretation that the physiological and psychological effects of the increase will be identical for both children.

It is obvious that the final and ultimate interpretation of increases and decreases in motility can be made only after more intensive research studies have been carried out. The point we are raising is one which has very fundamental biological significance. Further research aimed at the solution of such an important problem should be made. Our facilities have not enabled us to do more than to present the results of our studies of the problem given above and to indicate, in the next chapter, some reasons for believing that changes in motility *in either direction* indicate increased fatigue. Fatigue increments, produced by impaired noc-

turnal rest, have certain social and biological consequences that are of the highest importance for normal health and growth in childhood. To further assist in appraising the movie results, we present the results of studies on experimental insomnia. This should be studied in conjunction with the present chapter.

9. Conclusions

1. Successive groups of children were shown fifty-eight different motion-picture programs in the evenings before retiring. There is a change in sleep motility which is a consequent of viewing the film and is not due to the "holiday" effect or to "normal" periodic variations in motility.

2. The change in motility during the night after seeing the film may be either in the direction of increase or decrease. The increases occur more often than the decreases. Either sort of change represents a state in which the normal recuperative function of sleep is reduced (cf. Chapter VII).

3. Increases in motility of a relatively small number of added active minutes per hour have great effect on the average length of the quiet periods. This influence is to reduce them, whereas in recovery from all fatigue states they need to be lengthened.

4. Increases in motility following the movies ranged from 0 to over 90 per cent. On the average, boys showed about 26 per cent and girls about 14 per cent greater hourly motility after movies than in normal sleep. Some notion of the significance of a 25 per cent increase in motility for boys can be gained from the fact that this increase is equal to *half the normal amount of increase* resulting from the average growth changes occurring between the ages 8 and 15.

5. The changes in motility are greatest in the fore part of the night, that is at the time when sleep is at its maxi-

mum. Increased motility in the fore part of the night is not compensated by increased quiet in the latter part of the night. Recuperative sleep lost during the night following a motion picture brings the child to the new day incompletely recovered from fatigue. The amount of increased fatigue is a highly individual characteristic.

6. Children below about ten years of age show relatively less influence from the movies than do older children. The younger children frequently exhibit decreases in motility. Since this effect is characteristic of depressor drugs and of fatigue (insomnia not induced by movies), we may conclude that the movie effect on younger children probably differs in kind from that observed in older children who are perceptually more mature.

7. Roughly about two and one half times as many children show significant increases from all types of films as show corresponding decreases.

8. The movie influence is not limited to the one night immediately following the viewing of the film. The persistence of the effect is dependent upon the age, sex, and "set" of the individual child. Evidence supporting these statements can be secured by the comparison of the Post-Movie and Normal columns in Tables 19 to 38, considered in the light of pp. 134 ff.

9. The magnitude of the movie influence does not seem to be so much a function of mental age or brightness as it does of chronological or physiological age. The maximal effects seem to occur at about the age of puberty.

10. On the basis of extensive interviews with the children, we conclude that below age ten the children prefer comedies and pictures of the wild west type in which there is swift action and relatively simple plot. From the more abstract stories they are able to report isolated facts and

episodes but frequently fail to comprehend essential relationships in the story, particularly in those more sophisticated dramas in which much of the story is developed in conversation rather than in pantomime. In general the testimony of children in such matters is of little value. After seeing a series of movies on consecutive nights the younger ones confuse the stories, names of personages seen, etc., to a greater degree than do the older children.

11. Matinee attendance, on theoretical grounds, should show as great effects on motility as night attendance, or even greater. We were not able to make the experimental comparisons because of the lack of facilities.

12. The movie influence is not limited to changes in motility during sleep. The extent to which the total impression effect from a film may be redintegrated later, to influence the course of subsequent thought or conduct, is not revealed by our technique. We can conclude, however, from our results that seeing *some* films does induce a disturbance of relaxed, recuperative sleep in children to a degree which, if indulged with sufficient frequency, can be regarded as detrimental to normal health and growth. For certain highly sensitive or weak and unstable children the best hygienic policy would be to recommend very infrequent attendance at carefully selected films. On the other hand certain films may have an instructive or cathartic and sedative effect that is good. We do not believe that any sweeping generalization can be made about the "type" of film, or "type" of child most likely to be influenced (excepting, of course, the abnormals). There is a distinct need for careful, intensive study on individual children's reactions to movies, observed over a longer time than we have had at our disposal.

CHAPTER VII

EFFECTS OF LOSS OF SLEEP

"I have been the whole day without eating, and the whole night without sleeping:—occupied with thinking. It was of no use. The better plan is to learn."—CONFUCIUS (*Analects*, Book XV, Chapter XXX).

1. PREVIOUS STUDIES

THE effects of loss of sleep have been the subject of religious, philosophical, medical, and psychological speculation from the earliest times, but the first careful psychological experiments with which the writers are familiar to be performed under controlled conditions are those of Roemer (193), Patrick and Gilbert (189), and Aschaffenburg (168).

Roemer and Aschaffenburg both studied the effects of loss of sleep on association. Responses based on sound similarity and other low-grade associations were found by Roemer to be increased as much as 25 per cent without increasing association time. Aschaffenburg found in Roemer's results partial confirmation of his own theory that fatigue from insomnia increases the tendency (*Erregbarkeit*) to merely motor response in place of more abstract associations; he says that the disagreement of Roemer's results with his own theory is only an apparent one.

Aschaffenburg showed that under the influence of exhaustion abstract, meaningful associations gave way to less meaningful associations based on rime, sound similarity, and mere long-accustomed usage. In general the higher mental functions gave way to the simpler. This suggests at once a similarity between the effect on mental

functions of extreme exhaustion and intoxication. Other investigators have pointed out other parallels that bear out the conclusion that the two states have much in common. We shall return to this point in a later portion of this chapter.

Patrick and Gilbert (189) kept three subjects awake continuously for 90 hours. A series of physiological and psychological tests was made upon them at intervals of six hours to determine reaction time, discrimination time, motor ability, memory, attention, and various other factors. All subjects increased in weight throughout the experiment, and the decrease afterward was less than the increase during the experiment. Reaction time of the second subject increased. The results for discrimination and choice reaction time were irregular and unsatisfactory. The first subject found it necessary to make up 25 per cent of the lost sleep, as measured by the time spent in bed at the conclusion of the experiment, the second required 16 per cent, and the third 35.3 per cent. One subject showed marked visual hallucinations, while the acuteness of his vision uniformly increased as the period of sleeplessness progressed, then fell below normal after sleep. The other two subjects suffered no hallucinations or serious discomfort. All subjects felt completely refreshed after a single night's sleep. The authors believed that the complete restoration was due to the greater depth of sleep (more rapid anabolism) and to partial sleep during the prolonged period of insomnia, the rate of partial restoration being greater than during ordinary waking moments. Where Michelson and Kohlschütter reported deepest sleep at the end of the first hour, as measured by the intensity of the sound stimuli necessary to awaken the subject, Patrick and Gilbert found deepest sleep at the end of the second hour, as measured by the time required for an induction shock to awaken the subject.

Legendre and Piéron (186) subjected dogs to experimental insomnia. The serum and cerebro-spinal fluid from normal dogs and from the dogs subjected to experimental insomnia were injected into other dogs. Physiological and histological observations convinced these experimenters that there is a hypnotoxic substance found in the dogs subjected to experimental insomnia which produces an imperative need for sleep in the normal animal into which the substance is injected. Hypnotoxic action appeared more intense in the cerebro-spinal fluid than in the serum, and it appeared also in the arachnoid. They also noted definite histological changes on post-mortem examination and state (1913) that these modifications are proportional to the need for sleep and ought to disappear when the animal is permitted to repose and sleep.

May Smith (195), interested in the effects of fatigue, subjected herself to periods of experimental insomnia on three successive nights. On the first night $1\frac{1}{2}$ hours of sleep were taken, on the second night $3\frac{1}{2}$ hours, and on the third night $5\frac{1}{2}$ hours, so that during the three nights less than half the normal amount of sleep was taken. Throughout the experiment performance on the MacDougall Dotting Machine was measured. In all of the dotting experiments it was found that fatigue resulted in improvement at first, followed by deterioration, then a slow return to normal efficiency, although during the period of lowered efficiency the subjective impression was that the performance was very good. Also in the case of word associations it was found that the immediate effect of fatigue was to reduce the errors, then an increase in errors was followed by a slow return to normal. Fatigue increased the number of changes in the perspective in the windmill illusion, when the attitude or set was to prevent changes. Learning and re-

learning were adversely affected by fatigue. So far as the experiment was continued, the speed of tapping repeated the course of the first two tests. Improvement was followed by deterioration, then a slow return to normal. Subjectively the result of fatigue through loss of sleep was a feeling of exaltation combined with an emotional belief in the power to conquer all things, although the muscular weariness became at times positively painful. It is concluded that fatigue estimated objectively involves two distinct phases: a phase of distinct stimulation when work demanding concentrated attention is more effectively done than under normal conditions and a phase of longer duration when the body is attempting to make good its losses. Subjective feelings bear no relation to objective demonstrations of fatigue. There is a suggestion that it is possible to become partially immune to the effects of fatigue. Smith reports that Weichardt has maintained that antitoxin is produced during normal activity. She finds that her results fit in with such a theory, as the later fatigue cycles seem less severe.

Robinson and Herman (191) noted that while Smith reported a temporary increase in efficiency following insomnia, this was contrary to the findings of Patrick and Gilbert. While the latter investigators report completely restored efficiency after a night's sleep following insomnia, Smith reports a complete recovery of subjective consequences of loss of sleep, but her objective results show that the process was slow, extending over several days. The writers tried to settle the disagreement. Three subjects were used, and the effects of going without sleep from the ordinary rising time of one day until the ordinary retiring time of the second night following, a period of 60 to 65 hours, was studied. The tests employed were the hand dynamometer, tapping, aiming, reading letters, and mental multiplication.

The main conclusion drawn from the results was that the tests were not affected by insomnia in any marked or consistent manner. In so far as the curves show any general effect, they show a deleterious one. The negative results are attributed either to the fact that the 60-hour insomnia period has no effect or that, feeling a lowered capacity, the subjects expend more effort on the tests during the period of sleeplessness. Indeed, compensation may account for the higher efficiency reported by Smith. In a second experiment Robinson and Richardson (192) used three women and twenty-two men in an insomnia group and two women and thirty-seven men in a sleep, or control, group, all the subjects being students. Their performances on forms 5, 7, and 9 of the Alpha intelligence test were compared on three successive days. The members of the insomnia group abstained from sleep during the first day and night and until the completion of the second testing. The results show no significant difference between the groups, suggesting again the effect of extra effort in the insomnia group. Nor was there any tendency toward shifts in the ranking of the insomnia group that would show that some were affected favorably and some unfavorably by insomnia. Subjective ratings on tiredness and effort were made. The insomnia group were but slightly more tired at the beginning of the experiment as judged by these subjective ratings, felt much more tired after the second day, and on the third approached the stage of weariness of the sleep group. The insomnia group gave more effort and showed more interest in the later tests. Nervousness, irritability, dullness, lightheadedness, and loss of motor control were prominent in the report of the insomnia group, as was also true in the earlier experiment. The futility of objective tests is stressed because of the masking influence of compensation.

Herz (175) was the first to study the effects of loss of sleep on motility. He served as his own subject and underwent a period of experimental insomnia lasting 80 hours. During this period temperature, pulse, respiration, and various other physiological variables were studied. During the course of the insomnia period neither temperature, pulse rate, nor rate of respiration showed variations worthy of mention. Such changes as did occur were in the nature of greater variability. Blood pressure and body weight showed only slight variations. Neither reaction nor discrimination (*Merkfähigkeit*) was altered. A sleep period of 14 hours following upon the period of experimental insomnia sufficed for complete recuperation, so the writer concludes that for a young adult with sound constitution a period of absolute insomnia lasting for a few days need have no injurious effect. Four motility curves are presented, which were obtained with the Nagel hypnograph. No careful quantitative analysis of these or other curves is presented in the article, however. The longest quiet period in the normal sleep curve was of one hour's duration and occurred in the first hour of sleep, the subject having retired at 11:00 P.M. The longest quiet period in the record of sleep motility taken immediately following the period of experimental insomnia lasted for 75 minutes, and occurred during the first hour and a half of sleep, the subject having retired at 2:00 P.M. The following night the subject retired at 9:00 P.M. and the longest quiet period, lasting for 54 minutes, occurred during the second hour of sleep, from 10:00 to 11:00. However, this period is preceded by half an hour of quiet from which it is separated by only a single slight stir. On the following night the subject retired at 11:15 P.M. The longest quiet period, of one half hour, occurred between 12:30 and 1:30. The curve on the third

night following the sleep deprivation period does not represent a return to the normal motility, but on the contrary shows much more activity throughout the curve. However, a valid interpretation of the significance of these curves is almost impossible because the normal curve was taken in February, while the experiment occurred in April, and we have been able to show from our own experiments that a seasonal increase in activity would normally be expected. Furthermore, the hours of retiring are different on each of the experimental nights. Even if it were not for these objections, the reliability of the record of a single night of normal sleep on a single individual would be exceedingly low.

Kleitman (177) subjected six male students to periods of experimental insomnia varying from 40 to 115 hours. He found that blood sugar, the alkaline reserve of the blood plasma, percentage of haemoglobin, the percentage of both red and white corpuscles, body weight, basal metabolism, appetite, temperature, ability to name letters, and ability to do mental arithmetic showed no variation from the normal during the insomnia period. A marked decrease in the respiration, heart rate, and blood pressure he attributes to a greater degree of muscular relaxation. Suggesting that there is some evidence that the diurnal temperature variation is due to the alternation of sleep and wakefulness, he reports that the temperature wave tends to be effaced during the prolonged insomnia. It is noted that while muscular relaxation induces sleep under normal conditions, it practically precipitates sleep under conditions of experimental insomnia.

Lee and Kleitman (185) report an experiment in which one subject underwent six sleepless periods ranging from 60 to 114 hours at different seasons of the year. The experi-

mental periods were separated by long control periods. It was found that the knee jerk was not affected by insomnia but promptly disappeared with the onset of sleep. The pupillary reflex persists practically unchanged during the insomnia but in dim lights of standard intensity the diameter is much smaller than the normal. The sensory threshold for faradic stimuli and the ability to react to auditory and visual stimuli, to name opposites, to multiply mentally,—all these show no change during insomnia, confirming the observations of Robinson and Herman, who used similar tests. The ability to name colors was not impaired during insomnia if the number of colors was small (100), but when the subject had to name 1200 colors in succession, he spent more time and made more errors in the insomnia period than in the control period, thus showing inability to sustain attention under these conditions. The power to maintain one's equilibrium, applying the graphic method to Romberg's test, showed marked deterioration during insomnia, but this was possibly due to muscular fatigue.

Laslett (182) studied the effects of loss of sleep upon ability to do mental work of three levels: simple retention of rote memory for digits, a substitution test (largely reducible to a reaction-time experiment with practice), and an analogies test requiring considerable thought and judgment. Two experiments were made, involving 50 hours of continuous wakefulness. The two experiments were similar in all ways except that the subjects were different. In the words of the experimenter, "the results are far from conclusive, perhaps even from definite." Many reasons are given for the negative results, including serious criticisms of the experiment. No spurt was noticed after the slight fatigue of the loss of sleep for one night, thus failing to confirm the results of Miss Smith.

Weiskotten (197) performed an experiment extending over 17 days, acting himself both as subject and experimenter. Memory for nonsense syllables, speed in adding, and accuracy as measured by cancellation of A's in Whipple's A Test were measured. A record was also kept of pulse rate and weight. The total period of insomnia was 62 hours. The effects of a bad cold were noticeable in the pulse rate, which therefore loses its significance. Lack of appetite preceding the experiment was replaced by a keen appetite at all hours during insomnia. He also noted a feeling of mild intoxication, which has also been reported by others, and a feeling of mental exaltation. He was reluctant to begin any sort of work, but once it was begun, sources of reserve energy seemed to be tapped. Evidences of disorganization occurred on the second night such as loss of motor control, dizziness, and light-headedness, as reported by Robinson and Herman. On the third day continued abstinence from sleep became a real suffering in the daytime. The body temperature dropped greatly, and a room temperature of 80° F. was required for comfort. On the question of depth of sleep following experimental insomnia Weiskotten differs from both Patrick and Gilbert and Robinson and Herman. At the end of the period of insomnia there was some slight difficulty in inducing sleep, in spite of the extreme fatigue, and the sleep which followed, although only of 14 hours' duration, was frequently broken. The character of the sleep was observed to be of no very deep nature. The sleep on the second night, while only 9 hours long, was more restful. In a test for memory and relearning, the trend of both curves is toward a reduction in time except during the period of insomnia, when the trend is upward. The same is true of the test for speed with reference to the latter part of the period of insomnia. The curve for accuracy fluctuates

so much that the effect of insomnia is scarcely noticeable, except that the lowest score occurs during the insomnia period. The pulse rate dropped from 74 to 52 per minute from the first to the last day of the insomnia period, and the vitality and body temperature were low. There is a gradual increase in weight even during insomnia, as noted by others. The increase in weight is attributed to the increase in appetite "as being evidence of nature's supplying the physical needs of the body through the appetite when unable to supply those needs through sleep." A comparison of all the curves shows practically no effects due to loss of sleep during the first half of the insomnia period except in the case of the test for accuracy, but during the latter half there was a rapid decrease in mental efficiency. After sleep was taken, the scores were better than before the period of insomnia, except that the score for the test of accuracy remains the same. On the whole the results conform more to those of Patrick and Gilbert and of Robinson and Herman than to those of Miss Smith.

The fatigue induced through loss of sleep to a certain point acts as an apparent stimulus upon the mental powers. Loss of sleep affects the mental powers to a considerable degree, acting upon them indirectly through diminishing the power of concentration. Memory and speed seem to be affected more than accuracy. From the findings obtained on the measurement of weight it would seem that to a certain extent nature restores the energy lost through lack of sleep and that latent stores of energy are drawn upon. It would therefore follow that the amount of sleep which can be lost without serious results would depend upon the constitution of the individual. Body temperature and pulse rate are both lowered by continued loss of sleep. It requires but little more than the ordinary amount of sleep to recuper-

ate from the effects of loss of sleep. The dangers accruing occur in cases where the loss is prolonged beyond certain reasonable limits or where such a loss is habitually repeated.

Leake, Grab, and Senn (184) fatigued rabbits to a point of collapse and death by depriving them of sleep. They note the symptoms of approaching collapse are a sudden fall in temperature, a rise in pulse rate above the normal level followed by sudden and marked fall, and a gradual fall in respiratory rate.

Kleitman (178) subjected puppies to experimental insomnia and found that there is direct as well as indirect evidence that anemia of the brain is not a necessary condition for sleep.

Laird (180) gave two groups of subjects 30 minutes' practice at mental multiplication. The insomnia group went without sleep the following night, while the control group took its normal amount of sleep. The following morning both groups performed mental multiplication for 30 minutes. In every case more errors were made by the insomnia squad, while the control squad made markedly fewer errors. Laird concludes that the failure of previous batteries of short mental tests to disclose the effects of loss of sleep may have been due to the fact that these effects were masked by the novelty and change of the tests, offsetting the deleterious effects.

Laird and Wheeler (181) report that while the loss of two hours of sleep will not be reflected in the performance in mental multiplication, a marked increase in the working caloric consumption can be measured during mental multiplication for subjects who have undergone this reduction. Two subjects showed increases of $7\frac{1}{2}$ per cent and 12 per cent between the resting and working caloric consumptions following the normal eight hours of sleep, while three

subjects suffering a loss of two hours of sleep on the previous night showed increases of 25.3, 25.5, and 56.1 per cent respectively for these same measures. This increase is attributed to increased muscular tension incident to the "concentration of attention."

Laslett (183) subjected four individuals to sleep deprivation involving 40 per cent reduction in their usual amounts of sleep on five successive nights. He found that the difference between systolic and diastolic pulse pressure for the two periods was not greater than some of the daily fluctuations. In a code writing test the average number of letters coded correctly in each 5-minute interval during the sleep ration period was 159.5 as compared to 162.2 for the four days immediately preceding the experimental period. An addition test also showed a slight decrease for the insomnia period. Two pursuit tests showed small decreases of performance during the insomnia period, although a study of the curves shows that the practice effects were still strongly operative. The scores made on the Thorndike intelligence examinations preceding the experiment were reduced by 14.9 per cent when the tests were repeated during the insomnia period. Reduced sleep ration produced a noticeable, but in many cases scarcely noticeable, effect upon the scores of the subjects in all of the tests. One night of the usual amount of sleep sufficed for recuperation.

In a second experiment Laslett used five subjects in an experimental insomnia group and two subjects in a control group. The insomnia group went without sleep for three days, and in this experiment the same tests were used as in the sleep ration experiment preceding. In addition to pulse rate, sublingual temperature, visual acuity, measurement of speed, and accuracy of eye movements, the Lowell modification of the Snellen letter charts, and an

astigmatism chart were included. It was found that systolic blood pressure fell on the whole throughout the experiment until the last reading, when four or five showed a rise in pressure. In four cases out of five the diastolic pressures were higher during the sleepless period than they were in the preceding or succeeding days. The pulse pressure difference indicates a load on the heart during the sleepless days. The averages of all subjects but one were lower on the code test during the sleepless periods, and errors of all but one were higher. The subjects solved fewer problems in the addition test. The effects of practice on the pursuit-meter were still operative during the sleepless period, but three subjects failed to maintain their level of performance, while two showed increased skill during this period. The amount of sway of all subjects was larger, as measured by the ataxiameter, during the sleepless period than in the days preceding. While visual acuity seemed to improve during experimental insomnia, the difference does not seem significant. After 56 hours the average scores made on Part 1 of the Thorndike intelligence examination showed a loss of 19.2 per cent from normal, and after 72 hours the loss increased to 24.6 per cent. The writer believed these to be less than the true losses, since the subjects were above average and found time to check through once or twice. After the experiment the longest period of uninterrupted sleep shown by any subject was 11 hours, while the average was slightly less than 9 hours. Laslett suggests that the field of the reflexes should be studied in connection with sleep deprivation, especially since they are little influenced by compensatory effort.

Weiskotten and Ferguson (198) quote Laird as saying that "when a battery of short mental tests is given to subjects who have been without sleep for one, two, and in

some cases three nights, no appreciable and consistent decrease in performance is reported," but point out that Laird's statement is not consistent with his findings. These experimenters used three subjects for an experimental group and two for a control group. The experimental group went two nights and part of the next day without sleep. Loss of sleep seemed in no way to affect the performance of any individual in ball tossing. The downward trend of the curve for "sensorimotor learning" (code test) during the insomnia period is marked, as is the greater variability. In abstract learning (multiplying) more time is required, and the variability increases during insomnia. The writers agree with Whiting and English that "fatigue is a conscious (if negative) motive to action. Fatigue does not directly cause work decrement but raises the threshold at which work motives are effective." The readings for body temperature, body weight, and pulse rate reveal nothing from which any conclusion might be drawn. "Perhaps the most significant of all the feelings reported by the group was the lack of inhibition displaying itself in a variety of subtle forms." There was no report of feelings of giddiness or mild intoxication such as were previously reported by Laslett and by Laird. The state of nervousness and irritability continued to increase as the sleepless period continued. The influence of companionship served to stave off the immediate effects of fatigue, which then tend to assert themselves at a later time, according to the writers. Loss of efficiency in the "mental functions" is said to be due to a breaking down of the powers of inhibition, demonstrating itself in a lack of concentration and an inability to fix attention for a very long period. Speed rather than accuracy seemed to suffer. The amount of sleep needed for recuperation was a little more than normal. Increased individual

variability and resultant instability seemed the most outstanding characteristics.

2. Summary of Previous Studies

Some twenty studies on the effects of loss of sleep on man have been made since 1896. Many of these investigations have secured data on but a single subject for a single period of experimental insomnia, the same individual acting as subject and experimenter. The periods of sleep deprivation have ranged from a partial reduction on successive nights (Smith and Laslett) to complete experimental insomnia for 115 hours (Kleitman). Most investigators report negative results for the types of tests that have been employed to detect the influence of loss of sleep on mental functions, it being generally agreed that fatigue is compensated for by extra effort. Small losses of sleep may lead to overcompensation and improved performance if the test employed is not unduly long (Smith, Weiskotten). All experimenters have shown that continued loss of sleep seriously impairs motor ability, with the exception of Weiskotten, who found no change in his ball-tossing experiment.

Smith and also Weiskotten report that memory and learning ability are adversely affected by loss of sleep, although Laslett's results were not conclusive. Findings were negative with respect to mental multiplication and naming colors so long as the number of colors used was not too great (Lee and Kleitman), for analogies and substitution tests (Laslett), and for the mental tests used by Laird. Adverse effects are reported for speed of adding and cancellation of A's (Weiskotten), code writing, addition, and intelligence tests (Laslett), transcribing into telegraphic code and mental multiplication (Weiskotten), mental multiplication and reading of letters (Robinson and Herman),

and naming of letters and mental arithmetic (Kleitman).

It is a common impression that sleep following experimental insomnia is deeper than normal sleep. Kleitman has demonstrated the presence of reflexes in post-experimental sleep, while Weiskotten reports difficulty in going to sleep following the period of sleep deprivation and that his sleep was frequently broken and not very deep.

Sensory functions do not seem to be impaired by loss of sleep. Irritability, light-headedness, nervousness, feeling of mild intoxication, blankness of mind, lack of inhibition, and fatigue that in some cases becomes positive pain are reported subjectively. Some report in addition a feeling of exaltation.

While Patrick and Gilbert and Weiskotten (1925) have found increases in body weight, Herz, Kleitman, and Weiskotten (1930) find no significant variations.

Legendre and Piéron believe that they have demonstrated the presence of hypnotoxin in dogs subjected to experimental insomnia.

Where the results of physiological measures are not negative, decreases are reported, although in general these data are very unsatisfactory. The psychological effects of sleep losses are clearer and more significant.

The amount of sleep that an individual will take voluntarily following periods of experimental insomnia has shown that there are wide individual differences in the effects of loss of sleep. Some individuals take only the normal amount of sleep on the night following the experimental insomnia, while others may take as much as eight additional hours. All report that they seem to be as completely refreshed on awakening as they ordinarily are after the normal night's sleep.

We have been unable to find a single previous study on experimental insomnia in children. We present following the results we have secured in two such experiments.

3. STUDIES ON EXPERIMENTAL INSOMNIA IN CHILDREN

IF the motion picture induces an impairment of normal sleep, it becomes important to know how the movie curves compare with those of an experimental insomnia. Knowing the nature of the sleep curves where the usual ration has been reduced, we are enabled to get some notion of the type of impairment of the normal sleep curve made by a reduction in the total stay in bed. Having determined the shape of the motility curves under normal conditions, what change in these curves would follow a reduction of say one third in the total number of hours of sleep? If the experiments were not limited to a single night but were repeated several nights in succession, what changes would be observed under such a condition?

In order to throw some light on questions of this type two experiments were made: one a part of Experiment VI, the other a part of Experiment VII. The general plan of these sleep-deprivation experiments was as follows: First, without warning, after the usual period of normal nights the children prolonged the day's activities by engaging in games, reading, solving mechanical puzzles, and similar activities between the hours of 9:00 and 12:00 in their respective recreation rooms. The experimenters were present during these hours and used every means to keep the children active and interested. During the 3-hour period of added wakefulness precautions were taken to prevent excessively active or boisterous conduct, so that the play was orderly and as near normal as we could succeed in keeping it. At a few minutes before midnight they were prepared for bed and were allowed to sleep until the usual time of arising (6:00 A.M.). In Experiment VI this

reduction of $33\frac{1}{3}$ per cent, or from nine hours to six hours of sleep, was continued for three nights, and in Experiment VII for five nights. This was then followed by five nights of normal sleep, after which the $33\frac{1}{3}$ per cent reduction in the ration was again made by having all of the children arise at 3:00 A.M., three hours before the normal time of arising. After dressing, making their toilets, etc., they engaged in play activities until breakfast time.

The coöperation of the children in these rather grueling experiments was a pleasant surprise to us. Instead of resentment and complaint, without exception the children accepted the conditions as a matter of course, and we experienced no difficulty whatever in carrying out the work as we had planned it. Thus in these two experiments we were able to secure on forty children a total of 280 child-nights of sleep in which eight different nights were reduced from nine hours to six by keeping the children awake three additional hours in the fore part of the night, and on six nights by having them arise three hours before the customary time. This body of data, therefore, represents not only the first study of sleep deprivation in young children, but presents extensive enough information to enable us to determine with a fair degree of accuracy the effect of such deprivation on the normal sleep curves, and stands as a basis of comparison for the movie data. We present the following curves (Fig. 29) which show graphically the data for these experiments. The averages likewise are shown in Tables 41, 42, 43, and 44.

While most of the children remained fully awake and quite alert throughout the deprivation periods, it was observed that those below ten years of age did become very drowsy during the last hours of deprivation, so that special incentives were required to keep them awake. Fol-

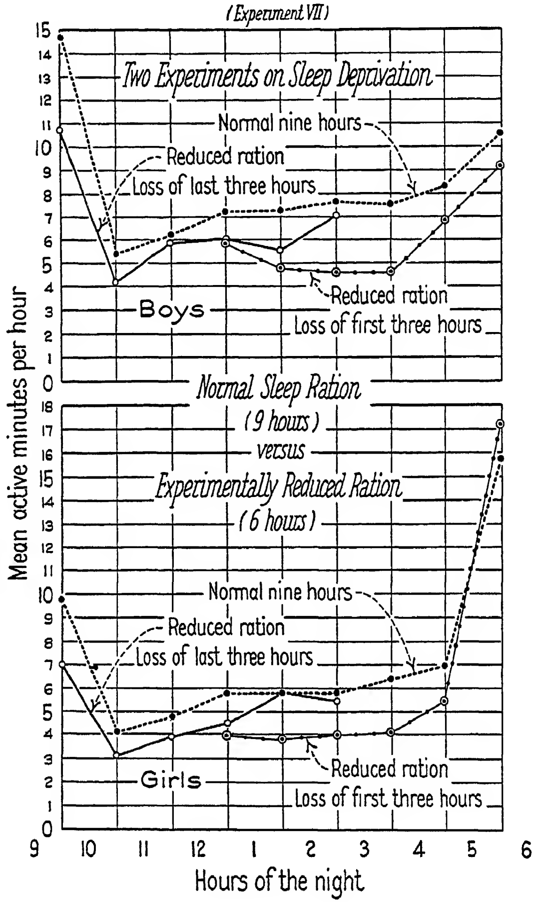

(Experiment VII)
Two Experiments on Sleep Deprivation
Normal nine hours
Reduced ration
Loss of last three hours
Reduced ration
Loss of first three hours
Boys
Normal Sleep Ration
(9 hours)
versus
Experimentally Reduced Ration
(6 hours)
Normal nine hours
Reduced ration
Loss of last three hours
Reduced ration
Loss of first three hours
Girls
Mean active minutes per hour
Hours of the night
9
10
11
12
1
2
3
4
5
6

FIG. 29

lowing the series of half a dozen nights on which the sleep ration had thus been reduced it became necessary to restore all the children to the ration of nine hours. The matrons and attendants at the Bureau reported that due to the effects of the continued loss of sleep many of the children became peevish and irritable, and the problem of conduct became an acute one. The gravity of this effect seemed to be inversely proportional to age, the greatest difficulties being shown in the case of the younger children. This observation gives support to the belief that the younger children do need more sleep than older ones. How much is undetermined.

It should be noted also that the institutional routine gives to each child, regardless of age, ten hours' sleep nightly. In order to keep uniform the conditions of our normal and movie experiments we arranged for our children to go on a 9-hour sleep ration throughout all our experiments after the first, as has been mentioned previously. The statement has been made by some alleged authorities that nine hours of sleep is not sufficient for children of these ages. A reference to Tables 1 and 3 will show the age distribution of the subjects in these experiments. We have no hesitancy in stating that so long as these children, aged about seven to eighteen, were permitted nine hours' stay in bed, no deleterious effects put in appearance. Our experience leads us to conclude that the optimal amount of sleep for a child of a given age is an undetermined value. An inspection of the normal sleep curves shows that all of the children in our experiments without respect to age or sex do show a progressive increase in motility from about the beginning of the last half hour of sleep, which clearly indicates the extent to which habit is a factor in determining the customary time of waking. This suggests the possibility that if the optimal durations

TABLE 41

RESULTS OF EXPERIMENT VI BY HOURS

Deprivation; Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys					Girls				
	Normal	Deprivation 1	Post-Deprivation 1	Deprivation 2	Post-Deprivation 2	Normal	Deprivation 1	Post-Deprivation 1	Deprivation 2	Post-Deprivation 2
9	15.4	*	18.5	16.4	9.8	10.8	*	11.8	11.0	7.7
10	5.7		4.2	5.4	5.4	4.9		5.5	4.6	3.8
11	5.9		5.9	5.1	5.6	4.1		4.0	4.4	4.0
12	7.4	8.7	7.0	7.6	6.0	5.6	7.7	5.7	4.5	5.2
1	7.7	3.8	6.8	5.8	6.2	6.0	4.3	5.4	6.4	5.5
2	7.3	5.4	7.4	8.6	5.9	5.8	3.2	5.3	6.1	5.1
3	8.0	5.2	6.3	†	6.9	6.5	5.1	7.7	†	6.3
4	7.3	6.9	7.3		7.0	6.8	5.3	5.9		5.8
5	15.7	8.1	9.6		12.3	15.9	8.5	19.8		19.2
Totals	80.4	38.1	73.0	48.9	65.1	66.4	34.1	71.1	37.0	62.6
Means	8.9	6.4	8.1	8.2	7.2	7.4	5.7	7.9	6.2	7.0

* The children slept only from 12:00 to 6:00.
† The children slept only from 9:00 to 3:00.

TABLE 42

RESULTS OF EXPERIMENT VI BY SUBJECTS

Deprivation; Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods

Subject No.	Boys					Girls				
	Normal	Deprivation 1*	Post-Deprivation 1	Deprivation 2†	Post-Deprivation 2	Normal	Deprivation 1*	Post-Deprivation 1	Deprivation 2†	Post-Deprivation 2
1	8.9	7.0	8.6	12.7		6.5	4.5	5.3	4.0	5.1
2	6.5	5.2	5.1	5.2	3.8	3.6	3.6	5.2	3.2	
3	6.4	5.5	5.4	4.4	4.3	5.3	4.3	5.6	4.6	4.7
4	9.4	3.6	6.0	6.9	8.1	6.8	6.3	8.9	4.7	7.7
5	10.9	7.0	11.0	9.1	8.2	6.5	5.3	7.8	7.2	7.1
6	13.4	9.5	12.2	10.9	9.4	8.8	6.6	7.8	9.2‡	7.6
7	12.2	9.8	12.1	12.1	11.7	8.8	5.4		7.6§	6.8
8	6.5	5.9	6.1	7.1	4.8	7.6	6.0	8.9	6.0	7.2
9	6.5	3.6	6.4	4.6	4.6	11.1	8.5	12.3	9.9	12.1
10	8.8	6.5	8.3	8.5	10.2	8.4	8.0	9.9	5.3	7.1
Totals	89.5	63.6	81.2	81.5	65.1	73.4	58.5	71.7	61.7	65.4
Means	9.0	6.4	8.1	8.2	7.2	7.3	5.8	8.0	6.2	7.3

* The children slept only from 12:00 to 6:00.
† The children slept only from 9:00 to 3:00.
‡ First night only.
§ Second night only.

Table 43

RESULTS OF EXPERIMENT VII BY HOURS

Deprivation; Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys					Girls				
	Normal	Deprivation 1	Post-Deprivation 1	Deprivation 2	Post-Deprivation 2	Normal	Deprivation 1	Post-Deprivation 1	Deprivation 2	Post-Deprivation 2
9	14.6	*	13.7	12.2	16.2	9.7	*	7.3	7.3	10.9
10	5.3		6.4	4.6	4.9	4.0		3.1	3.1	3.3
11	6.1		6.2	5.6	5.4	4.7		5.7	4.6	4.9
12	7.1	5.6	6.6	6.4	6.8	5.7	4.0	4.8	3.8	4.7
1	7.2	4.8	6.9	6.2	6.8	5.7	3.7	5.7	5.2	5.2
2	7.7	4.6	6.6	8.2	6.9	5.7	3.9	5.2	5.9	5.4
3	7.5	5.3	6.9	†	7.7	6.3	4.0	5.6	†	5.6
4	8.3	6.8	7.9		8.0	6.9	5.4	6.3		5.7
5	10.6	9.2	8.2		11.4	15.8	17.2	19.8		17.4
Totals	74.4	36.3	69.4	43.2	74.1	64.5	38.2	63.5	29.9	63.1
Means	8.3	6.0	7.7	7.2	8.2	7.2	6.4	7.1	5 0	7.0

* The children slept only from 12:00 to 6:00.
† The children slept only from 9:00 to 3:00.

Table 44

RESULTS OF EXPERIMENT VII BY SUBJECTS

Deprivation; Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods

Subject No.	Boys					Girls				
	Normal	Deprivation 1*	Post-Deprivation 1	Deprivation 2†	Post-Deprivation 2	Normal	Deprivation 1*	Post-Deprivation 1	Deprivation 2†	Post-Deprivation 2
1	9.6	7.0	9.4	9.5	10.6	4.5	5.2	5.3	4.1	5.4
2	6.5	4.2	7.0	6.1	6.4	7.4	7.2	7.4	5.7	7.6
3	8.9	6.8	10.9	8.9	9.5	6.3	6.1	7.0		7.7
4	9.6	5.1	7.2	6.9	9.4	6.9	6.5	7.2	5.3	7.0
5	7.6	5.8	6.3‡	4.9	7.7	10.5	8.2			8.9
6	10.1	9.0	8.6	8.7	10.2	7.6	6.8	8.2	5.2	7.3
7	7.5	4.5	7.1	7.2	7.1	8.0	6.1	8.9	7.1	
8	5.7	3.4	4.9	4.2	4.5	6.0	7.0	5.7	3.6	5.8
9	6.3	4.3	5.4	4.7	6.3	9.0	7.9	8.1	5.8	8.1
10	10.8	10.6	10.6	10.7	10.7	5.5	4.7	5.9	3.5	5.4
Totals	82.6	60.7	77.4	71.8	82.4	71.7	65.7	63.7	40.3	63.2
Means	8.3	6.1	7.7	7.2	8.2	7.2	6.6	7.1	5.0	7.0

* The children slept only from 12:00 to 6:00.
† The children slept only from 9:00 to 3:00.
‡ Only two nights.

of the sleep period for children of various ages were known, the normal sleep curves for these optimal durations might show an even greater similarity in pattern than do our own, where the sleep period was the same for children of all ages.

In Fig. 26 we present the individual curves of the twenty children in one of the two experiments. The curves represent the normal, movie, and deprivation motility patterns for each child.

4. WHAT ARE THE EFFECTS OF LOSS OF SLEEP?

FROM the foregoing experiments we note that sleep losses experimentally produced are followed by significant lowering of the group mean motility curves. The reduction is of an order greater than that observed from ordinary variations in the normal curves. There is no question that these children were fatigued at the midnight hour of retiring. They exhibited all or most all of the characteristic symptoms—some were "tired" and "sleepy," others were *apparently* fresh and were ready to prolong the period of wakefulness, although all of them had been awake for eighteen hours, that is since 6:00 A.M. We shall show now from other authoritative sources that this pseudo-freshness or alertness is a characteristic of certain degrees of fatigue and is a commonly known consequent of many so-called stimulating drugs which are in reality depressants.

We have already mentioned in this chapter that Kleitman observed that while the make-up sleep following deprivation was quieter, yet certain reflexes were elicitable which are normally absent in sound, restful, normal sleep. This fact would indicate that the decreases in motility consequent to greater degree of fatigue resemble the rest or sleep which follows the administration of soporifics.

There has been a considerable number of studies, both physiological and psychological, on depressor conditions such as those following the use of drugs or from long-continued activity which induce varying stages of fatigue, on alcohol, etc. From the writings of Verworn on irritability, Dodge on fatigue, R. S. Lillie on changes in the reactivity and conductivity of protoplasm following different conditions of stimulation, Fulton on muscle contraction, H. M. Johnson on the effects of altitude, and a number of other similar sources we may set down the following statements as indicating the prevailing views of a number of those scientists who have made the most careful studies of the problem:

1. Loss of sleep incident to forced waking beyond the customary time for retiring is a means of prolonging and increasing the fatigue state.
2. If insomnia is enforced for long periods, the degree of fatigue increases relative to the compensation effects produced by the chemical buffers of the body. Beyond the point of exhaustion of these substances there are degenerative changes, both functional and morphological. Definite changes in behavior are associated with even moderate degrees of fatigue. The factor of safety is, however, very great.
3. Fatigue states are identified with certain changes in the plasma membrane of the cell. These changes are in the nature of a change in the semipermeability of the surface film, usually a reduction in the permeability of the membrane to oxygen. Recuperation in the cell following reactance can only take place in the presence of oxygen. Fatigue, therefore, is a state of partial asphyxiation. In moderate degrees there is a resulting alternation of function consequent to fatigue and due to the presence in the cells of nonoxidized substances that are toxic.
4. Fatigue effects show a striking paradigm to the effects of narcotics and to oxygen deprivation. Many authors hold that the striking parallel of both physiological and psychological changes found in various degrees of fatigue is sufficient ground

for holding that there is no essential difference between fatigue and narcosis. Johnson cites, for example, the similarity of the "altitude jag" of the aviator, the elation, reversion to childish habits, hallucinations, and emotional instability from fatigue to the similar effects produced by alcohol, cocaine, heroin, hasheesh, and other narcotics. There is considerable likelihood that these manifestations differ only in degree, no matter how they are induced.

5. The first effects of fatigue, like those of alcohol or asphyxiation, may be "stimulating." But this is a false stimulation occasioned by the reciprocal dampening of "natural" and usually present inhibitors. The real effect is therefore always depressant. Larger doses or later effects of the same dose and extreme fatigue are always depressant. Goddard has pointed out that a similar and common fallacy attributes hypersexuality to the feebleminded. This error he believes arises because of the failure of mental defectives to exercise the customary inhibitions employed by persons of normal mentality. As an illustration of the apparent stimulating effect of fatigue, Johnson and Weigand (4, 176) made a code-translation experiment extending over two years, which showed that twenty-two subjects did 6 to 10 per cent better work a half hour before retiring than they did a half hour after arising. If longer time was spent in bed or if the subject showed increased quiet while there, the effect increased. We have already cited other experiments which indicate the point brought out by Dodge that fatigue is always relative and that its true effect cannot be gauged by work decrement, because of compensatory overexertion and lack of a definite point of reference, or zero point, among other considerations.

8. Fatigue increases perseverative movements, causing the reactor to continue doing the same thing even in the face of need for change. Johnson (176) reports that a tired driver near the end of a long journey is unable to stop driving and do other things. The driver curses stop-lights, over which he has no control, and may speak sharply to his companions and revert to uncivilized habits. Likewise a drunken person "may not be silenced or diverted." A fatigued person, according to Johnson, "may exhibit an abnormal appetite for the agent of de-

terioration." Illustrative of this point he cites the fact that tired children are the ones who fight hardest against being put to bed.

9. Johnson (176) asserts that "every effect of alcohol which has any social significance can be produced by some degree of fatigue. Physiologically the two conditions appear essentially the same; both are but special instances of cell asphyxiation."

10. Increased motility is therefore a manifestation of the same thing as decreased motility; namely, fatigue; partial asphyxiation; oxygen starvation; partial anesthesia. Any change in motility, whether increase or decrease, beyond the normal range of fluctuation is therefore an indication of fatigue. If a child shows decreased motility after a movie or sleep loss, this greater quiet may be a quiet of the same type produced by soporific drugs. It is not a more restful, recuperative sleep, as Kleitman's results tend to indicate. This fact is further evidenced by the fact that in sleep losses, although the quiet is greatly increased, the recuperation is greatly decreased, as is shown by the cumulative effect. We were forced to discontinue our experimental insomnia studies with these children because of the social effects produced by the physiological and psychological changes both on the children and the attendants.

11. We are now in a position to interpret in a different light the motility changes that were observed following the movies. Of the ninety-four children who saw a total of fifty-eight different films 33½ per cent of the girls and 44 per cent of the boys show, for the entire night, 15 per cent or greater increases or decreases in motility following the movies. Fifty five and one-half per cent of the girls and 62½ per cent of the boys show, for the first five hours of the stay in bed, 15 per cent or greater increases and decreases in motility following the movies. A similar-sized change (Experiment V, p. 134) was shown to be significant statistically to the extent that its occurrence by chance could be expected not oftener than once in 200 times.

5. CONCLUSIONS

1. SLEEP DEPRIVATION amounting to one third of the normal ration shows a different effect in the case of children from that generally reported in the previous studies

made on adults where the experimental insomnia period was considerably greater.

2. The effects of the loss of sleep in children extend into several nights following the deprivation period and are reflected in the post-deprivation curves, whereas practically all investigators report that a single night is sufficient for complete recovery from the effects of insomnia periods lasting as many as 115 hours in the case of adults.

3. All children show significant reductions in mean hourly motility as a result of the loss of a third of the usual night's sleep over a period of three to five nights. This effect is comparable to the effect of certain soporific drugs (luminal) observed by Karger. It is noteworthy that some movies produce as great effects in the direction of immobilization as those following the experimental insomnia.

4. If the loss occurs in the fore part of the night, the effect on the curve is greater than if the loss is occasioned by earlier rising.

5. Girls show greater quiet after sleep deprivation in the fore part of the night than boys; this relation is reversed in the latter part of the night. Yet the girls are quieter than the boys at all hours.

6. The general shape of the group curves remains approximately the same in deprivation as in the normal condition. The effect of loss of sleep in the fore part of the night seems to be to telescope the curves, thus reducing the total time spent in the region of low motility.

7. The younger children showed the most marked effects from loss of sleep. These effects seemed to be cumulative, causing increased peevishness, more frequent quarrels, etc., during the days following, which led after five nights to the necessity of returning the children to the normal 9-hour quota of sleep for a few days.

8. Frequent loss of sleep in amounts equivalent to one third of the normal ration, occasioned particularly by late retiring, will almost certainly lead to disturbances in conduct and to physical conditions detrimental to health in children. Younger children and children of weak constitution or nervous temperament will show these effects in greatest degree.

9. Further motility studies after the loss of varying amounts of sleep, correlated with careful measures of certain physiological functions, should be made upon children, particularly those of school age.

10. Significant increases of fatigue, whether induced by sleep impairment following the movies, from overwork, from narcotic drugs or alcohol, or any source of oxygen deprivation, are detrimental to health and growth, not only because of their known physiological consequences, but also because of the fact that the important inhibitory controls which serve to prevent misconduct are weakened. Frequent indulgence may lead to the formation of the habit of craving further indulgence. The best hygienic regulations for children should therefore include, among other things, only infrequent attendance at selected types of motion-picture programs.

11. Fifty per cent of the boys show *half as much or more change from the normal in motility* after seeing *all* types of movies as they show following loss of the first third of the night from enforced waking. Many individuals show even greater change after certain impressive pictures. Thirty-five per cent of the girls show change in motility following all types of pictures *equal to or greater than* that resulting from loss of the first third of the night.

12. Boys show an average change in motility of 45.5 per cent and girls 21 per cent after the loss of the first three

hours of the night. Fifteen per cent deviation from the normal may be taken as a significant variation (p. 134). Sixty-three per cent of the boys and 56 per cent of the girls show change, following movies, equaling or exceeding the change occasioned by the loss of the first third of the night. The experimental insomnia results indicate that loss of sleep in this amount is positively detrimental to health and conduct. An equivalent effect may be produced by seeing certain types of motion pictures.

CHAPTER VIII

INFLUENCE OF COFFEE

We have given consideration to the problems of "normal" sleep, to the effect of motion pictures, and to the comparative influence on both normal and movie sleep of an experimental insomnia. In this chapter we shall examine the extent to which a commonly used drug, caffein citrate, taken as coffee, influences the sleep motility of children. This comparative effect should give additional information to assist in the interpretation of the results described in the previous chapters.

1. Previous Studies

While it is a common impression, supported by medical sanction, that coffee has a deleterious effect upon growing children, when one investigates the scientific literature on the subject he is surprised to learn that very little quantitative work has been done to support this popular notion which seems to have arisen from casual uncontrolled observation, to be perpetuated by traditional prejudice.

It is also generally agreed that coffee, especially if indulged in before retiring, retards the onset of sleep even for adults and may lead to a restless night. Here again careful quantitative work is lacking. It would seem reasonable to assume that manufacturers who have invested a large amount of capital in the production and advertising of decaffeinated coffee should have at hand a considerable amount of definite information on the alleged detrimental effects of caffein, caffeo-tannic acid, and various

other coffee ingredients on sleep. Although the harmful effects of coffee on sleep are stressed in its advertising, the manufacturer of one of the most widely advertised brands of decaffeinated coffee supplied no information other than a vague allusion to medical literature, in a reply to one of the writers, who had written for more definite information on the ill effects of coffee on sleep.

Taylor (219) obtained statistics on 464 school children to study the effects of coffee on school grades. He found that 29 per cent drank no coffee at all, 46 per cent drank a cup a day, 12 per cent drank two cups, 8 per cent three cups, and the rest four or more cups a day. He found the following relations:

	No Coffee	Coffee
Conduct	75.6	73.1
Lessons	73.4	70.8

Since the figures for conduct in this tabulation are based upon subjective ratings and the figures for lessons depend partly upon this factor, their value is questionable. Even if we grant the validity of these estimates, it must be admitted that the decrease in the scores of the coffee drinkers hardly represent a valid difference, and as Max F. Meyer (214) has pointed out, "He (Taylor) does not prove that they (the children) have been stunted exclusively or chiefly or in any degree by coffee drinking. He fails to emphasize that coffee-drinking children are quite likely to have inferior parents."

Taylor also claims to have found slightly lower values for weight, height, and strength of grip for the ages from eight to twelve for coffee drinkers. He admits that in any case the effects of coffee drinking cannot be regarded as the same as of habitually taking caffein, it being generally agreed that the latter leaves no bad after-effects.

Hollingworth (205) has shown that small doses of caffein alkaloid (1 to 4 grains), taken either in pure form or accompanied by small amounts of syrup, do not produce appreciable sleep disturbance as measured by introspective judgments except in a few individual cases. Doses larger than these induce marked sleep impairment with most subjects, though even here a few individuals show complete resistance to its effects. The effects are greatest when the dose is taken on an empty stomach or without food substance, and when it is taken on successive days to permit of cumulative effect. He also reports that the effect of the drug does not seem to depend on the age, sex, or previous caffein habits of the individual, but varies inversely with increase in body weight. These conclusions, he claims, hold both for the quality and the amount of sleep.

Poffenberger (216) reports Frankfurter as finding increased efficiency in typewriting resulting from tea and caffein. This is in agreement with the experiments of Hollingworth (206) on the influence of caffein on mental and motor efficiency. Based on a review of the literature, Meyer (214) concludes that *general addiction to or abstention from coffee or tea seems to make no appreciable difference in the effect of a dose.* It makes a difference whether the stomach is empty or full, and a given dose is claimed to have less effect on a heavier body. Coffee strengthens certain functional properties of the nervous system. Its effect increases with the size of the dose. An overlarge dose, after a short time of increased efficiency, is likely to result in decreased efficiency. The effect of caffein increases during the first hour, is still noticeable after four hours with little decrease, and may last a while longer. Its effect on sleep is said to follow the same course. A very small dose, however, is not likely to interfere with sleep. The exact

rise and fall of the time curve of this drug is a problem of the future. The positive effect, however, does not seem to be followed at any time by a negative reaction. The drug seems, like alcohol, to affect the higher centers more than it does the lower ones. Meyer reports Schilling as finding that reaction time increases with coffee, but this is probably due to its effect in causing impatience and loss of interest.

Fetterman, Shillinger, and Irvin (302) report that the Pittsburgh District Dairy Council in coöperation with the Mellon Institute surveyed by questionnaire the milk and coffee-drinking habits of over 80,000 students. The following average figures were obtained on children of the first to eighth grade:

	Glasses of Milk per Day	Cups of Coffee per Day
City schools:		
Public	1.47	0.81
Parochial	0.93	1.52
County schools:		
Public	1.58	0.72
Parochial	0.89	1.37

It was found that in general the amount of milk consumed decreases and the amount of coffee increases with age. It is suggested that the striking difference between the public and parochial school children may be due to different racial dietary habits. The increase in coffee consumption with age was greater in the parochial groups. Of those who drank only coffee, nearly twice as many had it for breakfast as had it for lunch or supper. The authors agree with Taylor that those children drinking "coffee only" are found to be lower in scholarship than those drinking "milk only," as based upon teachers' ratings. Here again the extent to which coffee is a causal factor remains to be demonstrated. It has been suggested that lack of milk may be the more important factor, and that the drinking of coffee, coupled

with the lack of milk, indicates and accompanies generally unsatisfactory food and hygienic conditions. It was found that there was a less definite correlation between beverage habits and class standing in the case of students in the parochial schools, but it is suggested that this may be due to the fact that these children drink only coffee; hence milk was taken by too few children in the group to demonstrate as much favorable influence from its use as was observed in the case of the public-school children. Those from good homes drank 2.13 glasses of milk and 0.31 cup of coffee, while the others drank 1.19 glasses of milk and 1.10 cups of coffee on an average, which supports the criticism mentioned above. The District Dairy Council concludes that the advantages of the substitution of milk for coffee at breakfast should be stressed as well as the impropriety of the use of coffee at any time for school children.

Irvin (208) after an extensive review of the medical literature states that "there seems to be no question in the mind of the medical world about not allowing tea and coffee to children." A number of medical writers would also curtail the use of these beverages by the aged because of their increased sensitiveness to drugs and tendency to insomnia. "To summarize, it may be said that many specialists believe that coffee may be used in strict moderation by the normal adult without apparent injury to health, but, as has been pointed out by numerous authors, coffee is unhygienic when used to excess and may be positively harmful in the case of nervous disorders. Limiting caffeinic beverages to the morning and noon meals is frequently advised, especially in the case of the aged." The prevailing view is that the caffein of coffee has a definite action on both the heart and blood vessels, but for the normal adult normal indulgence does not produce very pronounced effects.

Several agree that the pulse is retarded and the force of the heart's action is increased, although blood pressure is not altered. Caffein's diuretic effect is well known, although explanations vary greatly. Children are especially susceptible to the effect of coffee on the kidneys. Opinion is divided as to the influence of coffee on digestion. Caffein affects not only the cerebral centers, but also the sensory nerves and spinal cord, but in man the cerebral effect predominates. Irvin (208) reports Cushny as stating that "in man caffein stimulates the central nervous system, in particular that part associated with the psychical functions. The idea becomes clearer, thoughts flow more easily and rapidly, and fatigue and drowsiness disappear. Not infrequently, however, connected thought is rendered more difficult, for the impressions follow each other so rapidly that attention is distracted, and it requires more and more effort to limit it to a single object. If the quantity ingested is small, however, the results are a distinct benefit in intellectual work." Irvin also states that overindulgence in coffee leads to nervousness and insomnia, this latter probably being one of the most common and harmful effects of excessive coffee drinking. Coffee also stimulates respiration and speeds up metabolism. But caffein is rapidly oxidized or partially demethylated in the body and under ordinary dosage has no cumulative effect.

R. W. Schulte (218) reports that the depth of sleep is slightly diminished even by Kaffee Hag and is still lighter following indulgence in coffee, stronger coffee having a greater effect than weaker. The effect of the Kaffee Hag is regarded primarily as "psychological." However, as our own chemical analysis has shown, Kaffee Hag is not entirely free from caffein. Whether the small amount of caffein present is responsible for the effect cannot be de-

termined on the basis of present results, but as long as this possibility exists, there is no justification for a purely psychological interpretation.

2. TWO EXPERIMENTS ON THE EFFECTS OF COFFEE

SINCE conditions at the Bureau were very favorable for studying the influence of coffee on the normal sleep motility curve, we felt that we should take advantage of this opportunity to compare the effects of coffee with those of the other variables previously studied. This seemed especially desirable in view of the fact that relatively little quantitative work has been done upon the problem, Schulte's work being the only comparative study of the influence of coffee and decaffeinated coffee upon children's sleep with which the writers are familiar.

For three weeks or more preceding these experiments the only beverage the children had received was milk, which was served with every meal. It seems reasonable to assume, therefore, that the results of these experiments should not be influenced to any great extent by variations in the coffee-drinking habits of the children prior to their commitment to the Bureau. It will be recalled that the effect of a given dose of caffein has been found to be independent of previous coffee-drinking habits.

For our experiments we decided to use a widely advertised brand of coffee generally recognized to be of high quality, while we selected the American-made Kaffee Hag for our decaffeinated coffee. Fresh supplies of both coffee and Kaffee Hag were purchased at a neighborhood store specializing in good groceries. Our next step was to have adequate samples of both analyzed for caffein content by a competent chemist.[1]

[1] The analysis for caffein was made according to the Fendler and Stüber method in the *A.O.A.C. Methods of Analysis*, page 270.

The average of two determinations on both brands of coffee yielded the following figures for percentage of caffein citrate by weight:

A standard brand of quality coffee,	0.974 per cent
Kaffee Hag,	0.109 per cent

It is evident, therefore, that Kaffee Hag contains about one ninth as much of the caffein, which its advertisers claim is so detrimental to health and sound sleep, as one of the typical full-strength coffees. Since these coffees were purchased in the open market, they may be regarded as fair samples of both products.

In preparing both beverages we used one tablespoonful to the cup. It was determined that the average tablespoonful of coffee weighed 14.15 grams, while the same amount of Kaffee Hag weighed 11.75 grams. One cup of coffee, therefore, contained 2.12 grains of caffein, while one cup of Kaffee Hag contained 0.20 grains of caffein, slightly less than one tenth as much as the coffee. The dose of caffein citrate [2] required to produce a physiological effect is said to be about 5 grains. This is about two to two and a half times as much as is found in one cup of the coffee infusion, and twenty to twenty-five times as much as the amount found in a 180-c.c. cup of Kaffee Hag.

Experiments VIII and IX were made to compare the influences of these beverages on the normal sleep motility curve. In the first experiment thirteen nights of normal sleep were allowed for the establishment of the individual norms on the ten boys and ten girls constituting the experimental group. The age distribution in this and the

[2] Organic chemists and writers of textbooks on pharmacology and materia medica are by no means agreed as to the form in which caffein is found in coffee. The citrate is generally used in therapeutics as a diuretic and stimulant to the central nervous system.

succeeding experiment will be found in Tables 1 and 3. The boys and girls were now divided into two experimental groups, A and B, of five children each, maintaining so far as possible the same average age within each group. This division, however, was unknown to the children themselves. For the next five nights the A groups received one cup of coffee instead of one glass of milk with the evening meal, while the B groups received one cup of Kaffee Hag. After some consideration we felt that it would be best to permit the children to use as much or as little cream and sugar with these beverages as best suited their individual tastes, to avoid unwanted psychological factors. Throughout the experiments all of the children were required to drink the same amount of coffee or Kaffee Hag, the attendants and experimenters by careful supervision making sure that each child drank his entire cup. In most cases the children regarded this change in their diet as a special privilege, although one or two of the younger girls expressed their dislike for coffee, and said they thought coffee was bad for children!

For the following five nights the A groups received one cup of Kaffee Hag, while the B groups received one cup of coffee with the evening meal. There was no indication that the children were able to distinguish the two beverages by taste, and as they were unaware of the fact that a decaffeinated coffee was being used, no suspicion was aroused. We do not wish to imply that a subtle difference in the tastes of the two beverages cannot be distinguished by a connoisseur.

Following upon this second series of five nights of coffee and Kaffee Hag with the evening meal for B and A groups respectively, all of the children resumed the usual glass of milk with the evening meal and all received one cup of coffee

at 8:30 P.M., shortly before retiring. It seemed reasonable to assume that if the effect of the coffee was an inverse function of time, then taking coffee just before retiring should show a greater effect than taking it with the evening meal, especially since it has been claimed that the presence of food in the stomach tends to diminish the influence of caffein. The further possibility suggested itself of giving all of the children one cup of coffee with the evening meal and one additional cup at 8:30. This procedure was followed for the next five nights. Here we should naturally expect a double dose to have a greater effect than either of the single doses alone.

Before proceeding to a consideration of the results of this experiment, which are summarized in Tables 45, 46, and 47, we shall describe a similar experiment performed on a second group of twenty children, ten boys and ten girls, so that the results of both experiments may be discussed together.

In this experiment (IX) fifteen nights were allowed for the establishment of individual norms. On the sixteenth day the "holiday effect" described in Chapter VI was introduced. Since all records had returned to normal after the second night following, we proceeded with a second experimental comparison of the effects of coffee and Kaffee Hag. In this experiment all of the twenty children received one cup of Kaffee Hag in place of the usual glass of milk with the evening meal for two nights in succession. One night of normal sleep followed, then all of the twenty children received one cup of coffee in place of the usual glass of milk with the evening meal for two nights in succession. This was followed by five nights of normal sleep. The results of this experiment are shown in Tables 48, 49, and 50.

TABLE 45

RESULTS OF EXPERIMENT VIII BY HOURS

Effect of Coffee and Kaffee Hag; Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys								Girls							
		Coffee								Coffee						
	Normal	A		B		At 8:30	Double	Post-Coffee	Normal	A		B		At 8:30	Double	Post-Coffee
		Real	K. Hag	Real	K. Hag					Real	K. Hag	Real	K. Hag			
9	18.0	24.3	17.4	20.1	17.8	17.6	17.3	13.4	11.2	16.2	16.6	12.8	20.9	19.2	19.5	11.2
10	6.8	6.3	5.0	7.4	5.6	9.0	8.1	4.6	5.0	6.0	5.2	3.7	8.5	6.3	7.1	4.5
11	6.4	5.5	5.2	6.1	5.9	8.4	6.6	5.8	5.1	6.3	4.1	5.6	7.2	6.6	5.4	5.4
12	6.5	7.4	6.0	7.6	5.6	5.5	7.7	7.3	6.2	6.9	5.4	5.4	4.6	6.1	6.1	5.5
1	6.7	7.1	7.8	8.0	6.2	7.0	7.3	6.4	6.5	8.2	5.6	5.6	7.1	5.4	8.4	6.5
2	6.8	6.9	6.0	6.1	4.9	8.0	6.9	6.7	6.7	9.6	3.8	6.3	9.1	7.1	7.0	6.0
3	6.8	7.0	7.7	6.7	5.9	5.9	6.0	7.0	7.2	8.7	6.7	5.8	7.3	6.7	6.1	6.7
4	7.7	5.6	7.5	8.5	6.6	7.7	8.0	7.3	7.3	8.5	5.8	6.4	7.2	8.0	6.7	6.9
5	14.7	10.3	10.9	14.5	10.1	12.8	11.1	11.6	22.8	19.3	20.9	17.5	21.2	18.0	18.3	17.3
Totals	80.4	80.5	74.5	85.0	68.5	81.9	79.0	70.1	78.0	89.7	74.0	69.3	93.2	83.4	84.6	70.0
Means	8.8	9.0	8.3	9.4	7.6	9.1	8.9	7.8	8.7	10.0	8.2	7.7	10.4	9.3	9.4	7.8

TABLE 46

RESULTS OF EXPERIMENT VIII BY SUBJECTS

Effect of Coffee and Kaffee Hag; Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods

Subject No.	Boy								Girl							
		Coffee								Coffee						
	Normal	A		B		At 8:30	Double	Post-Coffee	Normal	A		B		At 8:30	Double	Post-Coffee
		Real	K. Hag	Real	K. Hag					Real	K. Hag	Real	K. Hag			
1	9.1	9.1			8.9	7.2	8.2	8.0	6.2	6.7			6.5	8.5	7.9	5.0
2	7.1		6.9	8.1		7.0	9.4	6.1	8.8		8.5	8.0		8.9	10.1	8.3
3	7.5	7.4			6.6	7.0	8.0	6.8	10.2	10.3			10.8	10.5	11.2	9.4
4	8.0		7.4	6.6		9.2	7.2	6.2	9.7		11.9	8.6		6.9	9.9	8.7
5	11.1	10.5			9.4	10.6	11.2	8.0	11.0	12.4			11.5	14.2	11.1	9.4
6	10.1		8.8	11.1		9.4	9.2	10.2	6.2		5.7	5.9		5.2	5.4	4.6
7	8.9	12.6			9.3	12.4	9.2	7.1	9.8	11.0			10.3	9.2	12.2	9.1
8	8.9		8.4	8.4		9.7	8.6	9.4	7.2		7.5	8.7		9.2	7.8	6.7
9	7.1	5.0			3.8	6.4	4.2	3.8	11.2	11.9			12.7	13.5	11.9	10.9
10	11.6		9.8	13.3		13.8	12.5	12.4	6.2		7.4	6.4		6.3	6.4	5.6
Total	89.4	44.6	41.3	47.5	38.0	92.7	87.7	78.0	86.5	52.3	41.0	37.6	51.8	92.4	93.9	77.7
Mean	8.9	8.9	8.3	9.5	7.2	9.3	8.8	7.8	8.6	10.5	8.2	7.5	10.4	9.2	9.4	7.8

Table 47 is to be read as follows: Boy No. 1, who was 7 years and 1 month of age and weighed 46 pounds, averaged 21.6 minutes of activity during the first hour of sleep (9:00 to 10:00 o'clock) for the thirteen nights of normal sleep. For the same period he showed an average of 5 minutes of activity during the second hour of sleep (10:00 to 11:00) and 4.3 minutes of activity during the third hour, etc. During the five nights on which he received coffee with the evening meal he showed an average of 15 minutes of activity during the first hour's sleep, 2.8 minutes during the second, etc. During the five following nights, on which he received Kaffee Hag, he showed an average of 10 minutes of activity during the first hour. During the four nights on which he received coffee at 8:30, there was an average of 10.5 minutes of activity, during the four nights on which he received coffee both with the evening meal and at 8:30 he showed an average of 9.3 minutes of activity during the first hour, and for the seven nights of normal sleep following, during which he received no coffee or Kaffee Hag, he showed an average of 6.3 minutes of activity for the first hour. Each figure in this table, therefore, represents an average of several experimental nights for the same individual. The odd-numbered subjects in Table 47 constituted group A, while the even-numbered subjects constituted group B. As noted above, during the first five nights of the experimental period the first group received coffee, while the others received Kaffee Hag. During the next five nights the A group received Kaffee Hag and the B group received coffee. In the table the data for coffee influence precede those for Kaffee Hag in all cases. This sequence was adopted merely for convenience of comparison and does not represent the chronological order for all individuals.

Table 47

EFFECTS OF COFFEE AND KAFFEE HAG ON SLEEP MOTILITY

Mean Active Minutes per Hour, Experiment VIII, All Periods, Sexes Separate

	Boys											
				Hours of the Night								
Periods	Subject	Age	Weight	9	10	11	12	1	2	3	4	5
Normal	1	7^{1}	46	21.6	5.0	4.3	4.6	4.7	4.4	3.0	4.4	11.5
Coffee				15.0	2.8	4.2	2.8	4.6	4.0	5.0	2.4	4.6
K. Hag				10.0	2.0	3.4	2.8	2.2	3.0	3.4	2.8	4.8
8:30				10.5	3.8	3.5	3.5	4.3	3.5	3.0	2.8	6.8
Double				9.3	2.5	3.3	3.3	3.3	4.3	3.5	3.5	4.8
Post-C				6.3	2.7	1.4	4.0	3.7	2.8	3.9	3.1	6.4
Normal	2	8^{1}	54	15.6	3.3	4.3	4.4	6.1	5.7	4.8	5.4	14.0
Coffee				17.8	3.6	4.2	9.8	8.0	6.4	4.0	6.8	12.6
K. Hag				25.8	3.2	3.8	3.8	4.4	4.8	4.0	3.0	9.6
8:30				14.0	2.3	6.3	5.0	5.5	4.3	6.3	6.0	13.5
Double				18.3	7.8	4.5	10.0	11.0	7.0	5.3	4.8	16.3
Post-C				13.7	4.1	3.6	3.6	5.0	4.0	5.1	5.3	10.9
Normal	3	8^{9}	53	22.2	3.3	4.2	3.7	7.3	5.0	5.6	6.2	10.4
Coffee				33.8	1.8	2.6	4.8	4.0	5.0	4.0	5.2	5.8
K. Hag				21.0	2.2	3.2	3.6	5.4	4.6	5.6	5.2	8.8
8:30				27.0	3.0	3.5	4.0	6.0	5.0	3.3	4.0	7.8
Double				27.5	2.5	7.5	4.0	8.3	9.8	2.8	4.5	5.0
Post-C				24.0	1.6	3.9	3.7	4.4	6.1	6.3	5.1	8.1
Normal	4	10^{0}	71	9.5	4.6	6.3	6.4	6.3	8.4	7.0	7.6	15.9
Coffee				9.4	3.8	4.6	5.4	7.2	4.8	6.2	6.0	11.6
K. Hag				9.2	5.8	6.2	6.0	7.8	7.0	8.4	10.0	6.6
8:30				9.0	5.3	7.8	4.5	8.3	6.8	8.8	17.3	15.3
Double				7.5	5.0	7.3	8.5	4.8	6.5	4.0	9.0	12.8
Post-C				5.9	4.3	5.9	6.3	4.1	5.7	6.6	7.0	10.4
Normal	5	11^{1}	70	18.3	12.8	12.2	8.5	7.2	8.2	9.3	9.2	14.6
Coffee				27.0	11.6	6.4	6.4	7.4	7.6	10.4	5.2	12.4
K. Hag				20.8	8.8	7.4	8.6	5.8	6.0	8.0	9.0	10.6
8:30				19.5	11.5	9.8	8.5	8.8	10.3	7.0	6.0	14.0
Double				25.0	10.8	7.3	9.8	11.0	8.3	7.8	9.3	12.3
Post-C				8.6	5.7	10.1	6.6	8.0	7.0	9.1	5.3	11.1
Normal	6	12^{10}	97	16.3	6.7	7.3	7.5	8.0	7.5	7.8	10.4	19.2
Coffee				24.0	11.6	6.2	6.8	8.2	7.0	7.4	14.0	15.0
K. Hag				17.0	4.0	7.4	6.0	9.4	5.8	7.6	9.4	12.6
8:30				19.0	6.5	5.8	7.0	6.8	7.0	6.8	9.8	15.8
Double				23.3	9.0	5.3	5.5	8.0	5.0	6.3	11.5	9.5
Post-C				12.7	5.9	8.4	8.0	10.3	8.9	10.0	12.9	14.4
Normal	7	13^{0}	63	23.6	7.2	5.6	6.1	6.2	6.9	6.5	4.9	13.4
Coffee				38.0	8.0	6.3	14.0	10.3	11.0	7.0	5.0	14.3
K. Hag				28.7	8.0	7.0	4.2	8.5	4.2	4.2	6.2	12.5
8:30				33.5	22.0	21.5	4.3	3.3	9.3	1.0	6.8	10.5
Double				24.3	10.5	10.8	7.3	4.8	4.8	4.8	7.3	8.3
Post-C				16.9	4.3	4.6	3.9	4.3	4.1	6.7	5.6	13.6
Normal	8	14^{2}	99	20.3	5.6	4.5	9.1	6.0	6.3	6.6	6.1	15.7
Coffee				17.2	3.2	4.8	6.6	6.0	7.2	7.0	7.2	16.2
K. Hag				16.2	4.2	8.2	5.8	7.4	6.2	7.0	8.0	12.4
8:30				14.0	3.5	6.5	5.5	8.8	13.5	6.8	8.8	20.0
Double				12.0	9.3	3.8	8.0	8.5	5.0	7.8	10.0	13.3
Post-C				22.6	4.4	6.4	11.9	6.3	6.7	6.7	7.1	12.3
Normal	9	17^{0}	111	9.5	6.4	7.7	8.1	7.1	8.4	7.2	10.7	16.9
Coffee				8.0	7.4	8.2	9.0	9.2	7.0	8.8	10.4	14.2
K. Hag				8.4	7.0	8.4	8.6	9.0	6.8	8.4	10.0	13.6
8:30				5.3	7.8	6.3	6.8	7.8	8.0	7.0	6.0	10.0
Double				7.5	8.5	7.5	6.8	5.5	8.3	7.8	8.8	13.0
Post-C				6.3	4.9	6.3	8.7	6.3	8.6	8.4	8.6	14.1
Normal	10	17^{7}	120	23.1	13.2	8.0	6.7	8.4	7.0	10.4	12.1	15.4
Coffee				32.0	14.8	10.8	11.2	10.8	5.2	9.0	8.6	17.0
K. Hag				18.6	7.8	5.6	8.6	10.0	6.0	11.4	7.0	13.4
8:30				24.3	23.8	13.5	6.3	10.3	12.3	9.5	10.0	14.5
Double				18.3	15.3	9.3	13.8	7.8	10.0	10.3	11.8	16.0
Post-C				17.1	8.1	7.4	16.6	11.1	13.4	7.6	13.3	17.1

TABLE 47—*Continued*

EFFECTS OF COFFEE AND KAFFEE HAG ON SLEEP MOTILITY

Mean Active Minutes per Hour, Experiment VIII, All Periods, Sexes Separate

	Girls											
				Hours of the Night								
Periods	Subject	Age	Weight	9	10	11	12	1	2	3	4	5
Normal	1	6^{7}	48	3.9	4.0	5.0	4.5	4.5	3.2	3.5	6.0	20.9
Coffee				7.0	3.2	3.8	3.6	6.8	5.6	4.2	4.6	21.4
K. Hag				12.6	5.8	3.4	2.6	5.2	4.4	4.2	2.4	17.8
8:30				12.7	3.5	8.5	8.0	3.5	6.5	8.5	9.0	16.5
Double				11.3	6.7	4.0	5.0	10.7	11.0	3.0	3.0	16.7
Post-C				4.9	2.6	3.6	4.9	4.7	3.4	3.0	3.4	14.9
Normal	2	7^{1}	91	12.7	5.6	4.3	6.7	7.1	4.9	6.7	6.2	24.9
Coffee				14.0	3.4	5.6	8.0	6.2	7.4	5.8	4.0	17.8
K. Hag				20.2	4.6	3.6	6.6	5.0	4.2	5.6	6.0	21.0
8:30				22.0	4.0	4.5	5.7	6.0	7.0	4.5	7.3	19.5
Double				31.0	5.5	5.7	4.7	7.7	6.0	6.2	6.0	17.7
Post-C				15.4	5.0	5.7	5.6	6.3	5.1	6.7	7.3	18.0
Normal	3	8^{9}	51	12.2	5.4	5.9	5.7	8.7	9.0	11.3	8.8	24.7
Coffee				13.2	6.4	7.0	5.8	11.6	7.8	9.2	8.4	23.6
K. Hag				13.0	5.8	14.4	7.6	6.6	9.6	7.4	8.6	24.2
8:30				18.7	6.0	5.2	6.2	7.0	10.2	9.0	9.5	22.5
Double				28.3	7.0	5.5	7.5	8.5	6.5	7.3	11.0	19.5
Post-C				11.9	5.6	6.7	8.0	8.9	6.8	6.6	11.6	19.3
Normal	4	9^{5}	58	12.3	6.0	4.9	9.0	4.9	7.6	9.0	8.8	24.6
Coffee				17.8	5.8	3.6	5.4	5.2	8.0	8.6	11.6	20.0
K. Hag				26.8	11.6	5.4	7.2	8.4	4.0	11.2	7.8	24.8
8:30				17.5	5.3	6.5	7.7	4.0	7.5	4.2	6.3	29.0
Double				16.0	7.3	2.3	11.3	10.5	8.3	7.0	7.7	18.7
Post-C				12.9	4.7	6.1	7.3	5.7	7.7	7.0	7.7	19.0
Normal	5	10^{4}	84	15.7	8.1	8.8	9.1	9.3	9.4	7.7	9.7	20.8
Coffee				22.6	9.2	7.8	10.8	6.0	14.6	7.8	8.2	24.6
K. Hag				26.4	12.6	6.0	4.0	8.8	11.6	7.6	6.4	19.8
8:30				29.7	18.5	11.5	7.0	6.0	10.3	8.3	14.3	22.5
Double				19.0	11.0	8.7	6.7	12.3	5.0	10.7	7.3	19.5
Post-C				17.6	5.9	8.1	4.9	6.3	7.0	8.0	7.6	19.1
Normal	6	14^{0}	110	9.0	2.5	2.7	3.2	3.9	3.7	4.4	4.6	21.5
Coffee				10.8	1.8	3.2	4.8	3.6	5.0	4.0	4.2	15.6
K. Hag				10.4	0.4	3.0	3.2	4.0	2.6	6.0	4.0	17.8
8:30				8.0	1.7	4.5	3.3	3.0	3.7	4.0	3.7	15.0
Double				7.3	3.3	3.5	4.5	5.3	2.8	3.5	5.5	12.8
Post-C				5.1	2.3	2.1	3.0	4.0	3.7	3.6	4.3	13.7
Normal	7	14^{9}	144	16.7	4.0	4.5	4.8	7.8	8.7	10.8	8.0	23.2
Coffee				19.8	5.2	6.0	7.6	7.8	10.0	9.8	8.8	24.4
K. Hag				27.6	11.0	3.0	4.4	5.8	8.8	5.8	7.6	18.4
8:30				20.3	6.3	6.5	7.3	4.0	6.0	6.5	8.5	17.5
Double				32.7	15.0	10.3	5.0	6.3	5.3	9.3	7.8	18.6
Post-C				16.0	4.4	5.0	6.7	7.3	7.4	9.0	7.3	18.4
Normal	8	15^{0}	128	6.1	4.6	3.7	5.7	6.0	4.6	6.4	7.0	20.7
Coffee				8.6	5.2	12.4	5.4	8.6	6.8	7.2	7.4	16.6
K. Hag				9.8	4.0	5.6	6.2	5.6	4.4	5.6	6.0	20.6
8:30				15.3	1.8	7.8	7.8	6.8	5.5	7.3	8.5	22.5
Double				6.8	5.0	5.8	5.3	9.0	11.3	3.8	5.0	18.0
Post-C				8.1	3.7	5.0	2.9	7.4	5.0	8.9	3.6	15.4
Normal	9	15^{0}	109	15.3	6.8	8.1	8.7	9.0	10.3	7.5	9.5	25.1
Coffee				18.2	6.6	7.0	6.8	8.6	10.2	12.4	12.6	25.6
K. Hag				24.8	7.4	9.2	4.4	9.0	11.2	11.4	11.2	26.0
8:30				28.3	13.0	8.3	6.3	10.5	11.5	11.5	9.8	22.8
Double				25.0	7.8	5.8	6.5	9.0	9.5	7.3	10.0	26.0
Post-C				12.9	7.0	8.6	7.4	10.3	9.3	10.3	11.4	21.0
Normal	10	18^{0}	114	7.4	3.0	3.2	4.4	3.5	4.9	4.0	3.8	21.2
Coffee				13.0	2.4	3.2	3.4	4.6	4.4	3.6	5.0	17.6
K. Hag				15.6	5.2	3.0	3.8	4.8	3.8	5.0	5.2	20.4
8:30				19.8	2.8	2.5	2.3	3.3	2.5	3.3	3.0	17.8
Double				17.3	3.0	1.8	4.8	4.8	4.3	3.3	3.3	15.5
Post-C				7.4	3.4	3.6	4.3	3.9	4.7	3.6	5.1	14.4

TABLE 48

RESULTS OF EXPERIMENT IX BY HOURS

Holiday Effect; Coffee and Kaffee Hag; Mean Active Minutes for All Hours of the Night, Experimental and Control Periods; Sexes Separate

Hours of the Night	Boys							Girls						
	Normal	Holiday Effect	Post-Holiday	Kaffee Hag	Post-K. Hag	Coffee	Post-Coffee	Normal	Holiday Effect	Post-Holiday	Kaffee Hag	Post-K. Hag	Coffee	Post-Coffee
9	20.4	30.6	15.3	25.2	30.0	30.2	23.7	14.0	18.6	8.2	20.1	8.7	15.6	13.9
10	6.0	16.4	5.8	6.2	8.9	10.2	7.9	5.3	4.6	4.4	5.8	5.6	7.3	4.9
11	7.6	5.8	6.5	6.7	6.3	8.8	8.1	5.6	3.9	5.6	5.0	4.5	4.6	5.7
12	8.7	6.7	8.0	10.8	6.8	9.4	8.8	7.0	6.3	4.5	5.0	6.2	5.8	5.8
1	8.7	8.3	11.3	11.3	8.3	8.7	9.0	7.0	6.6	6.6	5.9	7.6	7.7	6.8
2	9.3	10.0	8.2	9.3	9.3	11.7	9.8	6.6	5.1	4.6	6.6	7.3	7.1	7.0
3	9.0	8.1	10.0	9.0	10.0	8.8	9.8	7.2	8.0	6.5	6.2	7.1	5.7	7.2
4	9.7	11.4	9.7	10.0	9.8	9.9	10.6	7.1	6.9	7.0	8.4	6.7	8.0	7.6
5	19.2	16.8	18.3	13.8	14.9	18.0	20.8	19.3	20.3	22.8	16.5	11.6	25.6	21.9
Total	98.6	114.1	93.1	102.3	104.3	115.7	108.5	79.1	80.3	70.4	79.5	65.3	87.4	80.8
Mean	11.0	12.7	10.3	11.4	11.6	12.9	12.1	8.8	8.9	7.8	8.6	7.2	9.7	9.0

TABLE 49

RESULTS OF EXPERIMENT IX BY SUBJECTS

Holiday Effect; Coffee and Kaffee Hag; Mean Active Minutes per Hour for Individual Subjects, Experimental and Control Periods

Subject No.	Boys							Girls						
	Normal	Holiday Effect	Post-Holiday	Kaffee Hag	Post-K. Hag	Coffee	Post-Coffee	Normal	Holiday Effect	Post-Holiday	Kaffee Hag	Post-K. Hag	Coffee	Post-Coffee
1	8.5	10.3	7.2	11.6	8.2	9.2	14.0	9.4	9.8	8.1	*12.1		10.6	8.5
2	15.6	20.7	15.2	19.7	15.9	19.8	18.0	8.5	9.4	8.3	7.1	6.8	8.7	9.4
3	11.2	14.7	9.8	11.3	9.6	15.1	11.2	9.1	9.2	8.0	11.5	6.9	10.5	10.3
4	14.8	17.3	15.2	19.0	15.6	18.6	17.1	7.6	8.8	7.0	7.8	8.0	6.8	8.0
5	10.1	11.2	9.4	9.3	10.4	11.2	10.7	7.8	8.8	7.3	7.1	5.8	9.3	8.1
6	8.3	7.9	8.2	7.7	8.6	10.5	8.2	16.7	14.9	14.1	15.1	15.3	*15.4	15.4
7	11.1	Sick		9.4	8.6	10.1	10.6	6.7	6.6	5.5	4.7	3.2	7.8	5.9
8	13.6	13.3	11.3	10.3	11.9	12.7	11.3	7.2	5.6	7.9	6.4	6.1	9.1	8.7
9	6.1	7.4	6.5	5.2	6.7	*6.3	6.9	9.7	110.4	7.5	9.3	8.8	11.0	9.7
10	10.3	10.1	11.3	10.0	12.0	11.7	11.3	5.4	6.0	4.3	4.9	4.2	7.8	5.6
Total	109.6	112.9	94.1	113.5	107.5	125.2	119.3	88.1	89.5	78.0	86.0	65.1	97.0	89.6
Mean	11.0	12.5	10.4	11.4	10.8	12.5	11.9	8.8	8.9	7.8	8.6	7.2	9.7	9.0

* Only 1 night.

Table 50 is read similarly. The figures for normal sleep represent the average of fifteen nights for each individual, those on coffee are averages of two nights, and those on Kaffee Hag are also averages of two nights on which this beverage was given with the evening meal.

Both of these tables are worthy of careful study, as they show clearly the impossibility of drawing broad generalizations for the group as a whole. It will be noted that boy No. 10 in Experiment VIII shows an increase in motility over normal for the first five hours of the night during the coffee period, while boy No. 1 in the same experiment shows a corresponding decrease for the first six hours, although the decreases for the 11:00 o'clock and 1:00 o'clock hours are not significant. It will also be seen that boy No. 10 shows a very considerable increase in motility during the first three hours of those nights on which he received coffee at 8:30, and that the increases for the second and third hours are greater than for the corresponding hours of those nights on which he received coffee with the evening meal. A further interesting fact is that for boy No. 10 the effect of receiving coffee both with the evening meal and at 8:30 was to lower the level of the preceding curve for the first three hours of the night. For some the greatest effect seems to occur in the middle of the night, as in the case of boy No. 2, Experiment VIII, who shows an increase for the hours 12:00, 1:00, and 2:00 during the coffee period, although the hours 10:00 and 11:00 show no significant difference from the normal. Boy No. 1 shows a significant decrease for the entire night, with the exception of the 3 o'clock hour, under the influence of double coffee.

How are we to interpret such an effect when caffein is said to a stimulating rather than a depressing agent? Does the stimulating effect of coffee lead to overactivity before

TABLE 50

EFFECTS OF COFFEE AND KAFFEE HAG ON SLEEP MOTILITY

Mean Active Minutes per Hour, Experiment IX, Sexes Separate

			Boys								
			Hours of the Night								
Periods	Subject	Age	9	10	11	12	1	2	3	4	5
Normal	1	9^{2}	12.1	2.8	3.9	3.9	4.7	4.3	3.6	3.7	16.0
Coffee			13.0	4.0	9.0	9.0	2.0	7.0	2.0	5.0	6.0
K. Hag			8.5	4.0	2.0	4.0	2.0	3.0	3.5	7.0	12.5
Normal	2	10^{7}	16.1	4.0	5.5	5.9	6.5	6.1	8.5	6.9	15.1
Coffee			36.5	4.0	9.5	8.0	4.5	5.5	6.0	5.0	15.5
K. Hag			18.5	3.0	3.0	7.5	7.0	4.5	9.5	4.5	12.0
Normal	3	12^{6}	18.4	8.5	10.5	18.5	12.5	14.8	13.2	15.9	26.3
Coffee			34.5	9.5	9.0	13.5	15.0	19.5	14.0	20.5	31.5
K. Hag			31.5	8.0	14.0	19.0	20.0	22.0	23.5	17.0	16.0
Normal	4	12^{9}	20.4	4.8	10.2	13.6	11.4	13.1	10.5	12.6	26.2
Coffee			25.5	5.0	9.0	13.5	9.0	13.0	19.0	10.0	20.5
K. Hag			9.0	5.0	6.5	13.0	9.0	11.5	8.5	15.0	15.5
Normal	5	13^{2}	12.9	9.1	11.5	9.9	9.5	11.5	7.8	10.7	16.6
Coffee			18.5	9.0	8.5	9.5	5.5	9.5	9.5	13.0	18.0
K. Hag			17.0	6.0	3.0	8.0	11.0	11.0	8.0	8.5	12.5
Normal	6	13^{9}	20.6	5.1	6.4	8.9	9.7	8.5	9.7	10.4	13.2
Coffee			33.0	4.5	8.5	7.0	10.5	14.5	5.0	8.5	14.0
K. Hag			23.0	4.0	8.0	8.5	8.0	8.5	8.0	7.0	15.0
Normal	7	14^{8}	14.1	5.4	6.9	7.9	8.2	8.5	9.7	12.1	18.0
Coffee			29.0	7.0	6.5	9.0	13.0	7.5	7.5	14.0	17.0
K. Hag			12.5	4.5	4.5	11.5	8.5	7.5	11.5	8.0	15.5
Normal	8	15^{9}	24.3	7.2	7.0	8.7	8.3	8.9	7.4	9.1	19.8
Coffee			41.5	5.5	5.0	9.0	14.0	21.5	8.5	9.5	21.0
K. Hag			33.0	10.0	9.0	14.0	7.5	4.0	7.5	14.5	12.5
Normal	9	16^{2}	41.7	8.3	10.2	10.6	10.1	9.7	13.3	10.2	26.5
Coffee			49.5	40.5	15.5	12.0	9.0	12.0	8.5	10.0	21.5
K. Hag			55.0	14.0	14.0	11.5	25.0	15.0	5.0	9.0	19.5
Normal	10	16^{7}	23.3	4.7	3.9	4.3	6.1	8.0	6.3	5.3	14.7
Coffee			21.5	12.5	7.5	3.5	4.5	7.0	8.0	3.5	14.5
K. Hag			44.0	4.0	3.0	11.0	15.0	6.0	5.5	9.0	16.5

TABLE 50—*Continued*

EFFECTS OF COFFEE AND KAFFEE HAG ON SLEEP MOTILITY

Mean Active Minutes per Hour, Experiment IX, Sexes Separate

Girls											
			Hours of the Night								
Periods	Subject	Age	9	10	11	12	1	2	3	4	5
Normal	1	7[7]	11.4	4.3	5.0	6.1	7.3	5.7	6.5	4.8	19.0
Coffee			26.0	4.5	3.5	6.0	5.0	4.0	7.0	5.0	22.5
K. Hag			15.0	4.5	3.0	5.5	4.0	6.5	3.5	7.0	14.5
Normal	2	8[2]	8.9	4.5	4.8	6.1	5.2	6.2	5.0	6.7	17.3
Coffee			7.5	3.0	7.5	4.0	10.0	7.5	6.0	9.5	26.5
K. Hag			6.5	2.0	4.5	3.0	3.5	10.5	3.0	6.5	18.0
Normal	3	8[9]	12.9	3.1	3.7	4.8	4.9	4.3	3.8	5.4	16.4
Coffee			10.0	1.5	4.0	4.0	8.5	7.5	4.0	5.0	25.5
K. Hag			9.5	3.0	2.0	3.5	2.0	4.0	2.0	2.5	14.0
Normal	4	9[5]	10.2	2.5	2.1	3.1	3.8	2.8	3.5	4.0	14.8
Coffee			15.0	2.5	4.5	5.0	2.0	8.0	1.0	3.5	29.0
K. Hag			5.5	1.5	4.0	4.5	3.5	4.0	3.5	4.5	13.5
Normal	5	11[2]	13.1	6.4	5.1	7.2	6.3	6.3	5.6	6.6	20.0
Coffee			13.5	4.5	2.5	5.5	9.0	9.0	5.0	5.0	24.5
K. Hag			12.5	3.0	2.0	3.5	11.5	6.5	8.0	4.5	12.5
Normal	6	13[3]	25.5	5.9	5.9	5.4	6.1	4.6	6.5	5.3	19.2
Coffee			24.0	19.0	5.0	4.5	4.5	6.0	3.5	6.5	22.5
K. Hag			43.0	10.0	2.0	3.0	4.0	5.0	7.0	10.0	25.0
Normal	7	14[7]	10.5	3.4	5.1	5.8	6.5	5.4	6.3	5.9	20.0
Coffee			7.5	4.0	3.5	4.0	5.0	5.5	4.0	5.0	23.0
K. Hag			21.0	1.5	4.5	4.0	5.5	4.0	7.5	9.5	12.5
Normal	8	15[5]	15.6	4.9	5.6	7.4	8.9	7.1	7.7	6.9	18.0
Coffee			21.5	12.5	2.5	9.0	9.5	3.0	6.5	6.0	24.0
K. Hag			42.5	17.5	17.0	6.5	2.0	7.0	11.0	5.5	14.5
Normal	9	16[6]	11.7	6.4	7.0	7.8	8.3	7.0	8.2	9.3	21.6
Coffee			14.5	7.5	6.0	7.5	9.5	10.5	6.0	12.0	26.0
K. Hag			22.0	5.5	4.0	5.5	8.5	3.5	8.5	11.5	15.0
Normal	10	17[5]	20.0	11.2	11.5	16.4	13.1	16.1	19.2	16.5	26.3
Coffee			17.0	14.0	7.0	8.0	14.0	10.0	14.0	23.0	32.0
K. Hag			23.5	9.0	7.0	11.5	14.5	14.5	7.5	23.0	25.5

retiring, which is followed by compensatory quiescence? While this explanation might account for decreased motility when coffee is taken with the evening meal, it could hardly account for a similar effect when coffee is taken just before retiring, as is shown by boy No. 1, Experiment VIII, when coffee was taken before retiring, and when taken both with the evening meal and before retiring.

Numerous other combinations of these various effects occur for the different individuals, among which we may mention increases and decreases for the latter part of the night for coffee with the evening meal or at 8:30 or both, and also for Kaffee Hag; either increases or decreases for various parts of the night under the influence of Kaffee Hag, these changes being sometimes greater, sometimes less than the effect of coffee.

3. CONCLUSIONS

1. IN SO FAR as motility may be taken as an index of recuperative sleep, coffee does not have the consistent detrimental effect on the sleep of all children that it is generally assumed to have.

2. Individual differences in susceptibility to the influence of coffee are so great that it is impossible to generalize regarding the extent or direction of its effects on children of the same sex or of the same age.

3. For some children coffee affects sleep motility during the first one to three hours of sleep, for others during the middle of the night, and for a few children coffee seems to raise or lower the general level of the motility curve throughout the night.

4. The fact that Kaffee Hag seems to produce a greater increase in motility than coffee, for some individuals, would indicate that the extent of the effect is not a direct function of the amount of caffein in the two beverages.

5. Doubling the size of the dose within the hours 5:30 P.M. to 8:30 P.M. does not increase its effect for all individuals, and for some the effect is decreased, an effect analogous to that produced by overdoses of some poisons.

6. Coffee taken before retiring has less effect for some than coffee taken with the evening meal, a finding not in accord with the conclusion of previous investigators that the effect of caffein depends upon the amount of food in the stomach.

7. The effect of coffee does not appear to be proportional to the body weight of the subject, although the effects of caffein alone are proportional to body weight according to previous experimenters.

8. For some individuals there can be little doubt that coffee causes increased motility in sleep to a considerable extent (in some cases doubled for the first part of the night), while in other children of about the same age and weight no appreciable difference is noted.

9. Schulte's claim that the effect of Kaffee Hag is purely psychological is not borne out by our results. We find that while Kaffee Hag contains about one tenth the amount of caffein found in a standard brand of fresh coffee, nevertheless for some children it produces as great increments in motility, or even greater.[3]

10. Parents who would strongly protest against their young children ingesting from 4 to 6 grains of caffein between the hours 6:00 and 9:00 P.M. nevertheless permit attendance at motion pictures whose effects on sleep motility may be as great or greater than that of coffee and possibly more lasting in influence.

[3] The presence of of theobromine, tannic acid, etc., may be more responsible for undesirable effects than the caffein.

CHAPTER IX

THE CRITICAL FREQUENCY LIMEN FOR VISUAL FLICKER IN CHILDREN [1]

1. The Problem

The claim has been made that the intermittent illumination of the screen gives a flicker which induces eye-strain and nervousness in spectators at motion pictures, particularly in the case of children. If such could be proved to be the case, it is altogether possible that a certain amount of the increased "restlessness" of our experimental children might have been due to this factor. Since no satisfactory information could be found to settle this question from the literature, a suitable apparatus was developed and the experiments described in this chapter were made.

Soltmann (253) performed a series of experiments in which the muscles and motor nerves of newborn and adult mammals (dogs and rabbits) were stimulated by artificial electrical means, and found a characteristic difference between the reactions of young and mature animals. Among other things it was found that the muscles of the young were more highly susceptible to tetany, sixteen to eighteen stimulations per second producing continuous contraction in the newborn, while seventy to eighty stimulations per second are required to produce continuous contraction in

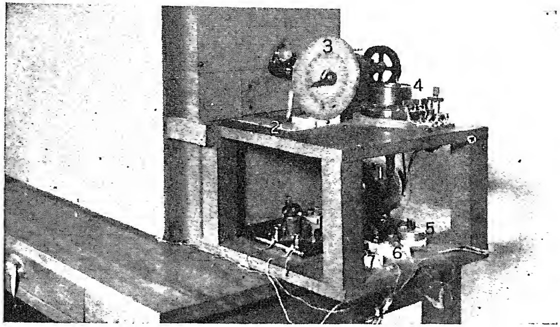
[1] This section is an abstract of a dissertation presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Ohio State University by Vernon L. Miller. Because of limited space we cannot review the history of this problem. For those readers who are interested we have presented a bibliography of thirty-six titles covering the most important related studies.

the adult. Koffka (240) calling attention to the above work, points out the analogy between fusion in vision and tetany produced by intermittent stimulation, holding that the conditions which determine the critical frequency in both cases are very much the same. Therefore he draws the inference that the critical frequency for fusion [2] in infants might be much lower than for adults. If this assumption is true, it has great theoretical importance. The present experiment was performed to determine whether such age differences could be demonstrated between the ages of six and eighteen years, and incidentally to determine whether the critical frequency limen was characteristically different for the two sexes. The problems of individual variability, diurnal variations, practice effects, and the influence of the loss of sleep upon the critical frequency limen were also studied. These problems have an obvious bearing on the question as to whether or not children are more likely to suffer eyestrain on viewing motion pictures than adults.

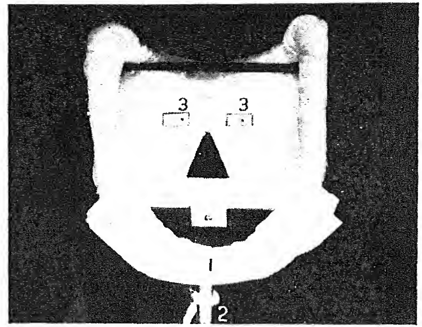
After a careful investigation of the literature on the critical frequency limen for visual flicker, the writer was unable to find a single study upon the critical frequency limen for children.[3]

[2] The critical frequency for fusion, or the critical frequency limen, is the point at which the speed of interruption of a continuous light source is so great that the interruptions (flicker) can no longer be discriminated.

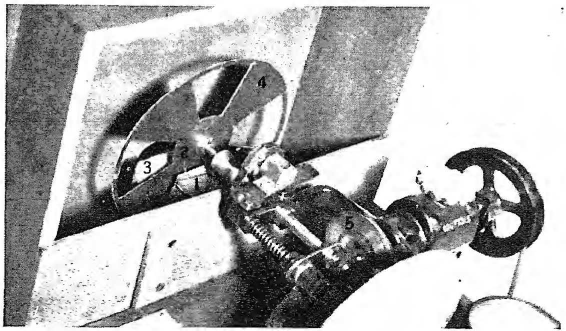
[3] Is Koffka correct in assuming that we should expect to find a corresponding change in the visual flicker and muscle tetanus limens with increasing age from infancy to adulthood? I believe not. The assumption would be correct if it should be shown that changes in the effector latency, refractory phase, etc., were of the same order as those in the efferent conductors, central distributors, afferent conductors, and in the sense organs. Herrick has shown, both in California hagfish and in the phrenic nerve in dogs, that the rate of discharge of the efferent conductor is imposed on the conductor by the effectors it innervates. But in the central mechanism and in the sense organ we note a decided difference. The sense organ is highly subject to "adaptation," while the afferent conductor is not. Changes at the myoneural junction incident to repeated stimulation, added to the variation in the irritability of the receptor, makes it inconceivable that there should either be a correspondence in any single age group between these limens or corresponding differences in successive age groups. Dr. Miller's findings support this view.—S. R.



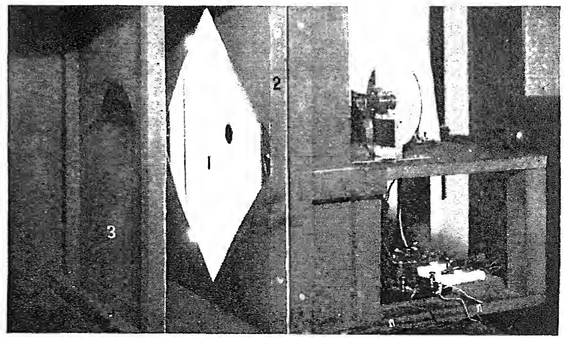
End View



Head-Rest



Speed-Reducing Mechanism



Interior View

Fig. 30

2. APPARATUS AND METHOD

To carry out this investigation an apparatus was constructed suitable for work on children. The apparatus was easily portable and provided its own dark room, by means of a light-proof tunnel (Fig. 30, 4) between the subject's head-rest and the flicker test-patch. A 21-c.p. automobile lamp (1, Fig. 30) enclosed in a black lamp house illuminated the test-patch (2, Fig. 30), which was a rectangular piece of opal glass 2.25 inches in front of the lamp filament, and one meter from the head-rest. The area of the test-patch was limited by a circular aperture 1.25 inches in diameter in a white cardboard screen (1, Fig. 30) 1.25 inches in front of the opal glass. This screen was illuminated by four 6-c.p. 6-volt d.c. automobile lamps mounted in the four corners of a frame (2, Fig. 30) immediately in front of the screen so as to provide an illumination of 5.44 foot-candles over a circular area 6 inches in diameter surrounding the test-patch. Constancy of the illumination of the test-patch and the surrounding field was assured by a constant check on the voltage (4, Fig. 30) of the two automobile storage batteries, which, in parallel, supplied the lamps with the direct current of 6 volts. Variations in the natural pupils were overcome by the use of artificial pupils (3, Fig. 30) 2 mm. in diameter, which also assisted in overcoming disturbances due to eye movements. An episcotister (4, Fig. 30) with four equal open and four equal closed sectors interrupted the light source at a point midway between the lamp house and the opal glass, providing equal light and dark intervals in each flicker cycle. This rotating disc was driven by a synchronous motor (1, Fig. 30), variations in speed being controlled by a friction-disc reducing mechanism (5, Fig. 30), which was provided with a calibrated scale (3, Fig. 30).

Preliminary experimentation demonstrated that transmitted light was more suitable than reflected light for making critical frequency determinations, and that when the direction of change was from flicker to fusion the readings were in better agreement than when the direction of change was from fusion to flicker. A continuous change in the speed of the episcotister was found to be more suitable than a step-wise change for making accurate determinations. It was also discovered that after fusion had been reported, the flicker would often return if the subject was permitted to continue looking at the test-patch while the episcotister was rotating at the same speed at which fusion had been reported. This difficulty was overcome by permitting twenty seconds for the reappearance of flicker after fusion was first reported. If the flicker reappeared, the rate of intermittence was increased until the flicker again disappeared, at which speed ten seconds were allowed for the reappearance of flicker. If it again reappeared, the rate of intermittence was further increased until the flicker again disappeared, at which speed a further ten-second interval was permitted for reappearance. This procedure was continued until a speed was reached at which flicker did not reappear during the ten-second interval. It was found that changes in the critical frequency limen due to dark adaptation could be largely overcome by providing a continuous bright field throughout a series of readings, and by permitting a rest interval of thirty seconds between the successive readings, during which time the test-patch was not illuminated. This procedure was followed in the experiment.

The method was as follows. Each child was required to learn to discriminate flicker and the point of its disappearance by observing a rotating disc composed of alternate equal black and white sectors, reporting the point of the

disappearance of flicker as the experimenter increased the speed of the disc in this preliminary demonstration. After the experimenter was convinced that the child had learned to make accurate discriminations, the demonstration was repeated, the child now observing and reporting the disappearance of flicker in the test-patch. Each subject made five determinations at a sitting, each determination or reading being separated by a thirty-second interval during which the test-patch was dark, although the field remained illuminated. Each determination was made in the direction of flicker to fusion, the subject indicating the point of disappearance by pressing a key in series with a telegraph sounder (Fig. 30). Following the method worked out in the preliminary experimentation successive intervals were permitted for the reappearance of flicker after its disappearance had been reported.

3. SUBJECTS

THE subjects, forty-four boys and thirty-four girls, were temporary residents of the Ohio Bureau of Juvenile Research in Columbus, Ohio. All had I.Q.'s of 80 or better and none had indices exceeding 20/40 in the Snellen Test of Vision. The consistency of their readings indicates that in all cases the vision of the subjects was sufficiently normal to make the determinations reliable. Since the discrimination of brightness differences, which is at the basis of the discrimination of flicker, is the most primitive response that the eye can make to light, it is not likely that minor variations in the auxiliary structures of the eye will appreciably alter the flicker limen. Each subject made five readings at a sitting, and three successive sittings on different days, or fifteen readings in all; 1170 separate readings were therefore taken in the normal series.

4. Results

When the means of the series of fifteen readings were determined for each subject, the results did not indicate any unequivocal trend in the direction of a higher critical frequency limen with increased age, as Koffka's inference suggested. This fact is clearly revealed by Fig. 31, in which ages are plotted against critical frequency limens. If the data are grouped by two-year intervals beginning with the interval from 5 years and 7 months to 7 years and 6 months inclusive, the data for the boys present no regularity of increase except from the age 13 years and 7 months upward, the last three two-year intervals having means of 2.326, 2.535, and 2.984 scale units respectively (0.05 approximately equaling one flicker cycle). Any regular trend for the girl's data is broken by high means for the interval 5 years and 7 months to 7 years and 6 months and the interval 13 years and 7 months to 15 years and 6 months. This latter rise for girls would seem to suggest the influence of adolescence, but the boys show a higher mean for the interval from 11 years and 7 months to 13 years and 6 months, than for the next lower and next higher two-year intervals, a fact not in keeping with such an interpretation. These irregularities, together with two exceptionally high individual means which have an undue influence on the means of the age groups in which they occur, and the small number of cases in two age groups for the girls, lead us to conclude that our data do not support the inference that increased age is accompanied by an increased critical frequency limen for visual flicker.

When the sigmas of the readings for each individual were expressed as percentages of the mean readings it was found that 67.5 per cent of the boys and 70.0 per cent of

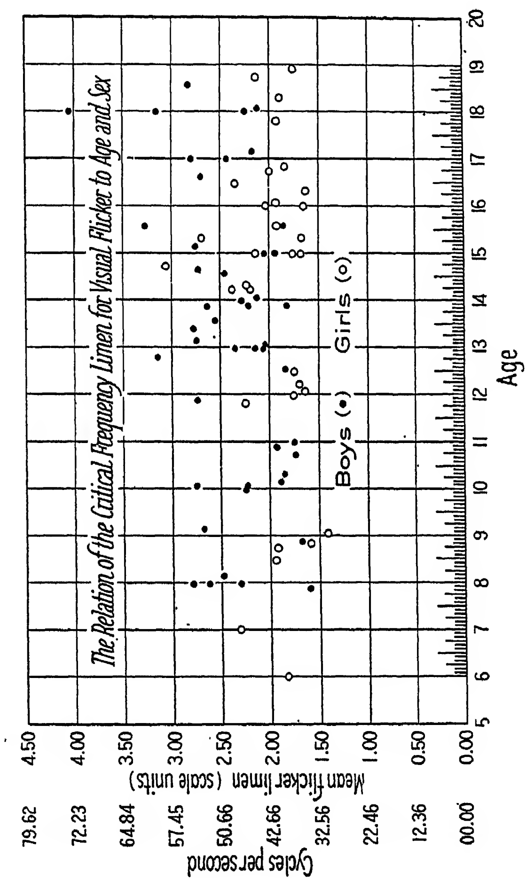

The Relation of the Critical Frequency Limen for Visual Flicker to Age and Sex
Boys (•) Girls (o)
Age
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Mean flicker limen (scale units)
4.50 4.00 3.50 3.00 2.50 2.00 1.50 1.00 0.50 0.00
Cycles per second
79.62 72.23 64.84 57.45 50.66 42.66 32.56 22.46 12.36 00.00

FIG. 31

the girls have sigmas of 10 per cent or less, which is especially low in view of the fact that the level of the readings varies from day to day. A study of the extent and direction of these day-to-day variations indicated that the majority of the boys showed an increase in the level of their readings from the first to the second and from the second to the third day, the means of the readings for the boys as a group being 2.201, 2.349, and 2.410 on the first, second, and third days respectively. The girls showed similar increases, the means for the girls as a group being 1.920, 1.985, and 2.139 on the first, second, and third days respectively. Only 6 of the boys and 3 of the girls show decreases from the first to the third day. This consistent increase in the limen from day to day must be attributed to the effect of practice. The practice effect is also reflected in a decrease of the variability of the readings on successive days, when the difference between the averages of the first two and the last two readings made at a sitting is taken as a measure of variability. This difference also indicates that the trend of the readings during a single sitting was upward for about two thirds of the subjects, although the extent of the change was very small. This slight change is probably due to adaptation which increases the physiological intensity of the stimulus, for it is known that increased brightness of the light phase of the flicker cycle raises the critical frequency limen.

An unexpected result of the study was the finding that for the boys as a group the critical frequency limen is higher than for the girls as a group, as may be seen from an inspection of Fig. 31, the mean for the boys being 2.401 and the mean for the girls 1.974 scale readings representing 48.6 and 42.0 flicker cycles respectively. However, as might be expected, there was some overlapping of the two

distributions. Forty-six and one tenth per cent of the boys have means above 2.40, while only 6.1 per cent of the girls have means above this point. The highest mean for the girls is 3.055, while four boys have higher readings, the lowest being 1.430. In general the readings for the boys as a group are more variable than the readings for the girls as a group.

In a second experiment the effects of the loss of the first three hours and the last three hours of the normal night's sleep on the critical frequency limen were studied. Ten boys and ten girls ranging in age from six to nineteen years served as subjects, having also participated in the first experiment. Under normal conditions the children had been retiring at 9:00 P.M. and arising at 6:00 A.M. In the experiments on sleep deprivation they either remained awake until 12:00 midnight (referred to as deprivation 1) and arose at 6:00 or retired at 9:00 and were awakened at 3:00 (deprivation 2), as described in Chapter VII.

It was found that the loss of the first three hours of the normal night's sleep lowered the level of the readings for four of the boys, and only one boy showed a very considerable increase from the normal to the deprivation period. The loss of sleep appears to retard the upward trend of the readings which was shown to be the normal result of practice, in those cases in which the level of the readings is not lowered. Readings were also taken on the days following the first deprivation period. Only two of the boys show a decrease in the critical frequency limen from the deprivation to the post-deprivation period, the general increase in the level of the readings during the post-deprivation period giving additional support to the conclusion that the loss of sleep was responsible for the lower level during the deprivation period. All but three of the boys show an in-

crease from the normal to the post-deprivation period, showing a return of the practice effect. The variations for the girls are very similar. Four girls show reduction of the limen from the normal to the deprivation period, while only two show a corresponding reduction from the deprivation to the post-deprivation period, one of these differences being negligible. Only one girl shows a reduction from the normal to the post-deprivation period. The chief difference between the girls and boys in this experiment is that the normal upward trend of the readings is less disturbed for most of the girls in spite of the loss of sleep.

In the second deprivation experiment, in which the last three hours of the normal night's sleep were lost, the effects are more pronounced. Six of the boys show a reduction of the limen from the normal to the deprivation period, and three show a reduction from the deprivation to the post-deprivation period also. Six of the boys show a reduction from the normal to the post-deprivation period. While only three of the girls show a reduction from the normal to the deprivation period, six show a reduction from the deprivation to the post-deprivation period, and five show a reduction from the normal to the post-deprivation period. It appears that there are wide individual differences in the effects of the loss of sleep but that loss of the last three hours reduced the limen over a longer period than loss of the first three hours of sleep.

Examination of the sigmas of the readings during the normal, deprivation, and post-deprivation periods reveals the fact that the loss of sleep does not markedly increase the variability of the readings and that for some individuals a progressive decrease in the variability of the readings throughout the three periods shows that the normal effect of practice in this respect has not been disturbed by loss of sleep.

During the second deprivation experiment readings were also taken on the ten boys immediately after they arose at 3:00 A.M. When the means of these readings were compared with the means of readings taken during the afternoon, it was found that five of the boys showed an increase and five showed a decrease in their limens during the day; although none of the changes was very great, indicating that there is no consistent trend in the readings from early morning to late afternoon that may be regarded as a normal diurnal variation.

5. BEARING OF RESULTS UPON MOTION-PICTURE PROJECTION

AT present, for sound accompaniment, motion pictures are projected at the rate of twenty-four pictures per second. The rotating shutter of the projection machine interrupts the beam of light thrown upon the screen twice for each picture, once while the picture is in position for projection and once during the transition from one picture to the next. The open sectors are somewhat larger than the closed sectors of the shutter, thus making the light interval relatively longer than the dark. The rate of intermittance, then, is 48 cycles per second.

The lowest mean reading for the boys was found to be 35 flicker cycles per second; while the lowest for the girls was found to be 31. The highest mean reading for the boys was found to be slightly below 73 cycles per second. However, this is exceptional, all but four of the boys having readings below 56 cycles per second. The highest mean reading for the girls is 59 cycles per second. However, all but two of the girls have readings below 48.5 cycles.

Three factors operate to bring the present rate of projection (48 cycles per second) within the critical frequency

range for both adults and children. (1) The dark phase of the flicker cycle in motion-picture projection does not represent zero brightness, but room brightness; (2) the light phase represents a much lower brightness than that in this experiment; (3) the range factor, the ratio of the difference between the light and the dark phases to the light phase, is lower than in this experiment because of the preceding two conditions. As a result the critical frequency of fusion is much lower. For this reason our results may not be taken as evidence that the present rate of motion-picture projection is too slow to give perfect fusion in children.

6. CONCLUSIONS

1. THE critical frequency limen for both sexes of all ages is sufficiently low so that the present rate of motion-picture projection should not result in the perception of flicker and should therefore not be taken to indicate that children suffer eyestrain from flicker in the motion-picture theater, or that the "restlessness" in sleep following the motion pictures was induced by this form of visual stimulation.

2. The results of this experiment, using forty-four boys and thirty-four girls, do not disclose a definite trend in the direction of an increase in the critical frequency limen for visual flicker corresponding to an increase in chronological age for either sex between the ages of six and nineteen years.

3. In general, the critical frequency limen for visual flicker is higher for boys than for girls, although there is some overlapping of the two distributions.

4. Practice reduces the variability of the determinations of the critical frequency limen.

5. In general, practice raises the critical frequency limen for both sexes, the magnitude of the increase being greater from the first to the second sitting than from the second to the third.

6. Loss of sleep slightly retards the increase in the level of the critical frequency limen in children which would normally result from practice, for some children, while it has no noticeable effect upon the limens of others.

7. The loss of the last three hours of sleep has in most cases a greater effect than the loss of the first three hours in retarding the normal rise in the critical frequency limen due to practice, as is shown by a fall in the level of the limen from the deprivation to the post-deprivation period for both sexes.

8. Loss of sleep does not noticeably increase the variability of the readings as might be expected. For some individuals loss of sleep in no way disturbs the normal decrease in the variability of the readings taken on successive days.

9. Diurnal variations during the deprivation period are small and show no consistent trend for the group of boys.

BIBLIOGRAPHY

1. Reviews of the Literature

1. Claparède, E.—Le sommeil et la veille. *J. de psychol. norm. et path.*, 1929, *26*, 433–493.
2. Johnson, H. M., and Swan, T. H.—Sleep. *Psychol. Bull.*, 1930, *27*, 1–39.
3. Johnson, H. M., Swan, T. H., and Weigand, G. E.—Sleep. *Psychol. Bull.*, 1926, *23*, 482–503.
4. Johnson, H. M., and Weigand, G. E.—Some recent experiments bearing on the problems of sleep. *Psychol. Bull.*, 1927, *24*, 165–167.
5. Same.—Sleep. *Psychol. Bull.*, 1930, *27*, 1–39.
6. Kleitman, N.—Sleep. *Physiol. Rev.*, 1929, *9*, 624–665.
7. Piéron, H.—*Le problème physiologique du sommeil.* Paris: Masson, 1913, pp. 520.

2. General

8. Editorial.—Shakespeare and sleep. *Brit. M. J.*, London, 1912, II, 1412.
9. Editorial.—The hygiene of sleep. *Brit. M. J.*, 1910, II, 1931.
10. Adrian, E. D.—Some recent work on inhibition. *Brain*, 1924, *47*, 399.
11. Armstrong-Jones, Sir R.—The value of sleep. *Practitioner*, London, 1929, *122*, 1–11.
12. Bass, M. J.—Differentiation of the hypnotic trance from normal sleep. *J. Exper. Psychol.*, 1931, *14*, 382–399.
13. Berggren, S., and Moberg, E.—Experimentelle Untersuchungen zum Problem des Schlafes. *Acta psychiat. et neur.*, 1929, *4*, 1–46.
14. Bresler.—Periodische Schlaflosigkeit. *Psychiat.-neurol. Wochenschr.*, Halle, 1919–1920, *21*, 107.
15. Bruce, H. A. B.—*Sleep and sleeplessness.* Boston: Little. Brown, 1915, pp. ix+219.
16. Burrell, R., and Bissett, C.—Sleep. *J. Med. Assn.*, So. Africa, Cape Town, 1929, *3*, 243–246.

17. CAMP, D.—Disturbance of sleep. *J. Mich. Med. Soc.*, Grand Rapids, 1923, *22*, 133–138.
18. CRUCHET, R.—Six nouveaux cas de rhythmie du sommeil (les rhythmes à la caserne). *Gas. hebd. d. sc. méd. de Bordeaux*, 1912, *33*, 303–308, 317.
19. DE MANACÉÏNE, M. M.—*Sleep: its physiology, pathology, hygiene, and psychology.* Scribner, 1897, pp. vii+341.
20. FEAGRE, MARION L., AND ANDERSON, J. E.—*Child care and training. Rev. ed.*, Minneapolis: Univ. Minnesota Press, 1929, pp. vi+274.
21. FERRON, L.—Sur un cas de rhythmie à la caserne. *Caducée*, 1913, *13*, 20.
22. FRASER-HARRIS, D. F.—*Morpheus; or the future of sleep.* London: K. Paul, Trench, Trubner & Co., Ltd.; New York: Dutton, 1928, pp. 94.
23. SAME.—Biology in Shakespeare. *Sci. Monthly*, 1932, *34*, 54–68.
24. FOX, S. J.—An analysis of sleep. *So. Africa M. Rec.*, Cape Town, 1926, *24*, 155–160.
25. FROBENIUS, K.—Ueber die zeitliche Orientierung im Schlaf und einige Aufwachphänomene. *Zschr. f. Psychol. usw.*, 1. Abt., 1927, *103*, 100–110.
26. GALLAVARDIN, L.—Troubles of first period of sleep. *Lyon méd.*, 1926, *138*, 587–595.
27. GALTIER.—Rhythmie du sommeil. *J. de méd. de Bordeaux*, 1912, *42*, 201.
28. GERBER.—Der Schlaf des Menschen und über einen praktischen brauchbaren Kontrollapparat. *M. m. W.*, 1922, 1399.
29. GROSS, M.—Sleep in relation to housing conditions and disease. *Med. Officer*, London, 1926, *36*, 95–97.
30. HARRIS, W.—The value of sleep. *Practitioner*, London, 1929, *122*, 18–20.
31. HOLLINGWORTH, H. L.—*Psychology of thought.* New York: Appleton, 1926, pp. 341.
32. HULL, CLARK L.—Quantitative methods of investigating hypnotic suggestion. *J. Abn. & Soc. Psychol.*, 1930, *25*, 200.
33. JOHNSON, H. M.—Is sleep a vicious habit? *Harper's Magazine*, 1928, *157*, 731–741.
34. KOTSOVSKY, D. A.—Elsueño y la vejez. *Rev. de criminol., psiquiat, etc.*, Buenos Aires, 1929, *16*, 92–96.

35. KŘIVÍJ, MIROSLAV.—Physiology and pathology of sleep. Part 1: Dreams from the psychological viewpoint and somatic changes (relaxation and changes of reflexes). Part 2: Various forms of hypersomnia. *Rev. v. Neurol. a. Psych.*, Praha, 1929, *26*, 281–298.

36. LAIRD, D. A., AND MUELLER, C. G.—*Sleep: why we need it and how to get it.* New York: John Day; London: Williams, 1930, pp. 234, 212.

37. LHERMITTE, J., AND TOURNAY, A.—Le sommeil normal et pathologique. *Gaz. de hop.*, Paris, 1927, *100*, 915–918.

38. MARINESCO, G., SAGER, O., AND KREINDLER, A.—Recherches expérimentelles sur le méchanisme du sommeil. *Bull. Acad. de méd.*, Paris, 1928, *100*, 752–756.

39. SAME.—Experimentelle Untersuchungen zum Problem des Schlafmechanismus. *Zschr. f. d. ges. Neurol. u. Psychiat.*, Berlin, 1929, *119*, 277–306.

40. MCDOUGALL, WM.—*Outline of abnormal psychology.* New York: Scribner, 1926, pp. xiii+566.

41. MEYER, MAX F.—*Abnormal psychology—when the other-one astonishes us.* Columbia, Mo.: Lucas Bros., 1927, pp. 277.

42. PAVLOV, IVAN.— Abstract of lecture on sleep. *Sci. Monthly*, Dec. 1923.

43. PHILLIPS, CATHERINE E.—*An anthology of sleep.* London: G. Chapman, 1924. (Compiled chiefly from the classical and English poets.)

44. RAVINA, A.—Le sommeil normal et pathologique. *Press. méd.*, Paris, 1928, *36*, 645–647.

45. RENSHAW, S., AND WEISS, A. P.—Apparatus for measuring changes in bodily posture. *Am. J. Psychol.*, 1926, *37*, 261–267.

46. REPONDEZ-MALÉVOZ, A.—Considérations psychologiques et psychopathologiques sur le sommeil. *Schweiz. med. Wochenschr.*, Basel, 1931, *61*, 63–67.

47. REXROAD, C. N.—Eye-movements and visual after-images. *Am. J. Psychol.*, 1928, *40*, 426–433.

48. ROSENTHAL, CURT.—Ueber den normalen Schlaf des Menschen. *Klin. Wochenschr.*, Berlin, 1927, *6*, 1457–1461.

49. RUSSELL, J. S. R.—The value of sleep. *Practitioner*, London, 1929, *122*, 12–17.

50. SCHENK, P.—Ueber das Schlaferleben. *Monatschr. f. Psychiat. u. Neurol.*, Berlin, 1929, *72*, 1–23.

51. SHERMAN, M.—The differentiation of emotional responses

in infants. I. Judgments of emotional responses from motion-picture views and from actual observations. *J. Comp. Psychol.*, 1927, *7*, 265–284.

52. SAME.—The differentiation of emotional responses in infants. II. The ability of observers to judge the emotional characteristics of the crying of infants, and of the voice of the adult. *J. Comp. Psychol.*, 1927, *7*, 335–352.
53. TARCHANOFF.—Observations sur le sommeil normal. *Atti dell XI Congresso Medico Roma*, 1894, *2*.
54. TEN CATE, J.—Zur Frage der Entstehung des Schlafes beim Menschen. *Zschr. f. d. ges. Neurol. u. Psychiat.*, Berlin, 1929, *122*, 175–186.
55. VON ECONOMO, C.—Studien über den Schlaf. *Wien med. Wochenschr.*, 1926, *76*, 91–92.
56. SAME.—Sleep as a problem of localization. *J. Nerv. & Ment. Dis.*, Albany, 1930, *71*, 249–259.
57. VON HEUSS.—Ueber eine Beziehung zwischen Muskeltonus, Aufmerksamkeit, und erschwertem Einschlafen im Hochgebirge. *Med. Klin.*, Berlin, 1913, *9*, 370.
58. W.—Sleep. *Brit. M. J.*, London, 1924, *1*, 39.
59. WASHBURN, M. F.—*Movement and mental imagery.* Boston: Houghton Mifflin, 1916, pp. xv+252.
60. WEYGANDT, W.—Experimentelle Beiträge zur Psychologie des Schlafes. *Zschr. f. Psychol. usw.*, Leipzig, 1905, *39*, 1–41.

3. THEORY

61. CLAPARÈDE, E.—Esquisse d'une théorie biologique du sommeil. *Arch. de Psychol.*, 1904, *4*, Génève: Kündig, 1905, pp. 104.
62. DUVAL, M.—Hypothèse sur la physiologie des centres nerveaux: théorie histologique du sommeil. *Sac. de Biol.*, 1895, *85*.
63. ERRERA, L.—*Sur le méchanisme du sommeil.* Brussels, 1895.
64. FOSTER, H. H.—A new standpoint in sleep theories. *Am. J. Psychol.*, 1900, *12*, 145–177.
65. HOWELL.—A contribution to the theory of sleep. *J. Exper. Med.*, 1897, *2*, 313.
66. JOHNSON, G. T.—Sleep as a specialized function. *J. Abn. & Soc. Psychol.*, 1923, *18*, 88–96.
67. JOHNSON, H. M.—An essay toward an adequate explanation of sleep. *Psychol. Bull.*, 1926, *23*, 141–142.

68. MARINESCO, G., SAGER, O., AND KREINDLER, A.—Beiträge zu einer allgemeinen Theorie des Schlafes. *Zschr. f. d. ges. Neurol. u. Psychiat.*, Berlin, 1929, *122*, 23–47.
69. NACHMANSON, D.—Zur Frage des "Schlafzentrums"; eine Betrachtung der Theorien über die Entstehung des Schlafes. *Zschr. f. d. ges. Neurol. u. Psychiat.*, Berlin, 1927, *107*.
70. SALMON, A.—*La fonction du sommeil.* Paris, 1910.
71. SMIRNOV, D. A.—The mechanism of sleep. *Vrach. dielo*, Kharkov, 1925, *8*, 2003–2008.
72. TRÖMNER, E.—Theories concerning sleep and the organ of sleep. *Deutsche Zschr. f. Nervenhk.*, *105*, 1928, 191–204.
73. VON ECONOMO, C.—Théorie du sommeil. *J. de neur. et de psychiat.*, 1928, *28*, 437–464.
74. VON ECONOMO, C.—Schlaftheorie. *Erg. d. Physiol.*, 1929, *28*, 312–339.
75. WOOLBERT, C. H.—A behavioristic account of sleep. *Psychol. Rev.*, 1920, *27*, 420–428.
76. ZWEIG, HANS.—Das Schlafproblem. *Zentralbl. f. d. ges. Neurol. u. Psychiat.*, Berlin, 1930, *55*, 353–373.

4. PHYSIOLOGY

77. BARR, A. D.—Relation of sleep to temperature. *Med. Rec.*, New York, 1890, *38*, 664.
78. BRUSH AND FAYERWEATHER.—Observations on the changes in blood pressure during normal sleep. *Am. J. Physiol.*, 1901, *5*, 199.
79. CARREL, ALEXIS.—Physiological time. *Science*, 1931, *74*, 618–621.
80. CLOËTTA, M., AND FISCHER, H.—Ueber die Wirkung der Kationen Ca, Mg, Sr, Ba, K, und Na bei intrazerebraler Injektion. (Beitrag zur Genese von Schlaf und Erregung.) *Arch. f. exper. Path. u. Pharmakol.*, Leipzig, 1930, *158*, 254–281.
81. CRILE, G. W., ROWLAND, A. F., AND TELKES, M.—An interpretation of excitation, exhaustion, and death in terms of physical constants. *Proc. Natl. Acad. Sci.*, 1928, *14*, 532–538.
82. DUBOIS, R.—Étude sur le méchanisme de la thermogénèse et du sommeil. *Ann. de l'Univ. de Lyon*, 1896, *25*.
83. SAME.—Le centre du sommeil. *C. R. Soc. Biol.*, 1901.
84. SAME.—Sommeil naturel par autonarcose carbonique. *C. R. Soc. Biol.*, 1901.

85. HESS, W. R.—Results of experiments locating cerebral excitations causing sleep. *Rev. oto-neuro-oft.*, 1930, *5*, 74–76.
86. KLEITMAN, N.—The effect of muscular activity, rest, and sleep on the urinary excretion of phosphorus. *Am. J. Physiol.*, 1925, *74*, 225–237.
87. KUNZE, J.—Die Veränderung der Hydrogenenkonzentration des Blutes während des Schlafes. *Zschr. f. d. ges. exper. Med.*, Berlin, 1928, *59*, 248–251.
88. LANDIS, C.—Electrical phenomena of the body during sleep. *Am. J. Physiol.*, 1927, *81*, 6–19.
89. LOMBARD, W. P.—The variations of the normal knee-jerk and their relation to the activity of the central nervous system. *Am. J. Psychol.* 1887, *1*.
90. MACKENZIE, I. C.—The circulation of the blood and lymph in the cranium during sleep and sleeplessness. *J. M. Sc.*, Jan. 1891.
91. MACWILLIAM, J. A.—Blood pressures in man under normal and pathological conditions. *Physiol. Rev.*, 1925, *5*, 303–335.
92. MARINESCO, G., DRAGANESCO, ST., ET. AL.—Recherches anatomico-cliniques sur la localization de la fonction du sommeil. *Rev. neurol.*, Paris, 1929, *36*, part 2, 481–498.
93. MILES, W. R.—Duration of sleep and the insensible perspiration. *Proc. Soc. Exper. Biol. & Med.*, 1929, *26*, 577–580.
94. PEIPER, A.—Untersuchungen über den galvanischen Reflex. *Jahrb. f. Kinderhk.*, 1924, *107*, 139 ff.
95. REED, C. I., AND Kleitman, N.—The effect of sleep on respiration. *Am. J. Physiol.*, 1926, *75*, 600–608.
96. RICHTER, C. P.—The significance of changes in the electrical resistance of the body during sleep. *Pract. Nat. Acad. Sci.*, 1926, *12*, 214–222.
97. ROSENBACH, O.—Summary of work on reflexes during sleep by Waller. *Brain*, 1882, *138*.
98. SHEPARD, J. F.—*The circulation and sleep.* Experimental investigations accompanied by an atlas. (Univ. Mich. Studies, Sci. Series, Vol. I.) New York: Macmillan, 1914, pp. ix+83.
99. STEVENSON, L., CHRISTENSEN, B. E., AND WORTIS, B.—Some experiments in intracranial pressure in man during sleep and under certain other conditions. *Amer. J. Med. Sci.*, 1929, *178*, 663–667.

100. TOULOUSE, E., AND PIÉRON, H.—Du cycle nycthéméral de la temperature dans la cas d'activité nocturne et de sommeil diurne. *Compt. rend. Soc. de Biol.*, Paris, 1906, *61*, 473–475.
101. TUTTLE, W. W.—The effect of sleep upon the patellar tendon reflex. *Am. J. Physiol.*, 1924, *78*, 345–348.
102. WALLER.—The galvanometric measurement of emotive physiological changes. *Proc. Royal Soc.*, 1918, B. *90*, 214–217.

5. MOTILITY AND RELAXATION

103. FUREY, G. W.—Muscular relaxation the cause of sleep. *Med. and Surg. Reporter*, Philadelphia, 1888, *58*, 333.
104. GINSBURG, M. S.—Investigation of night sleep by hypnographic method. *Moscow Med. J.*, 1927, *7*, 4, 1–6.
105. GUTTMANN, ERICH.—Aktogramme als klinische Schlafkontrolle. *Zschr. f. d. ges. Neurol. u. Psychiat.*, Berlin, 1927, *111*, 309–324.
106. JACOBSON, E.—*Progressive relaxation.* Chicago: Univ. Chicago Press, 1929, pp. 428.
107. JOHNSON, H. M., SWAN, T. H., AND WEIGAND, G. E.—In what positions do healthy people sleep? *J. Am. Med. Assn.*, Chicago, 1930, *94*, 2058–2062.
108. JOHNSON, H. M., AND WEIGAND, G. E.—The measurement of "sleep." *Proc. Penna. Acad. Sci.*, 1927, *2*, 43.
109. KUSSMAUL.—*Untersuchungen über das Seelenleben des Neugeborenen.* Tübingen, 1884.
110. LAMBRANZI.—Zit. nach de Sanctis: *Die Träume.* Halle, 1901.
111. PFEFFER, W.—Der Einfluss von mechanischer Hemmung und von Belastung auf die Schlafbewegungen. *Abhandl. d. math.-phys. Kl. d.k. sächs. Gesellsch. d. Wissensch.*, Leipzig, 1914, *32*, 161–295.
112. SAME.—Beiträge zur Kenntnis der Entstehung der Schlafbewegungen. *Abhandl. d. math.-phys. Kl. d. k. sächs. Gesellsch. d. Wissensch.*, Leipzig, 1917, *34*, 1–54.
113. PRATT, K. C.—Relation of temperature and humidity to activity in newborn infants. *J. Genetic Psychol.*, 1930, *38*, 480–484.
114. ROSETT, J.—An apparatus for the induction of muscular relaxation. *Arch. Neurol. & Psychiat.*, Chicago, 1929, *22*, 737–745.
115. SCHALTENBRAND, G.—The development of human motility and motor disturbance. *Arch. Neurol. & Psychiat.*, 1928, *20*, 720–730.

116. SZYMANSKI, J. S.—Aktivität und Ruhe bei Tieren und Menschen. *Zsch. f. allg. Physiol.*, 1919, *18*, 105–162.
117. VIRCHOW, H.—Bewegungen Schlafender. *Sitzungsb. d. phys.-med. Gesellsch. zu Würzburg*, 1883, 67–78.
118. WADA, TOMI.—An experimental study of hunger in its relation to activity. *Arch. of Psychol.*, 1922, *57*, 65.

6. DEPTH

119. CZERNY.—Beobachtungen über den Schlaf im Kindesalter und physiologischen Bedingungen. *Jahrb. f. Kinderhk.*, 1892, *33*, 1.
120. SAME.—*Jahrb. f. Kinderhk.*, 1896, *41*, 337.
121. DE SANCTIS, S., AND NEYROZ, U.—Experimental investigations concerning the depth of sleep. *Psychol. Rev.*, 1902, *9*, 254–282.
122. HAAS.—Ueber Schlaftiefenmessungen. *Psychol. Arb.*, 1923, *8*, 228.
123. KOHLSCHÜTTER.—Messungen der Festigkeit des Schlafes. *Zsch. f. rationelle Med.*, 1863.
123a. SAME.—Mechanik des Schlafes. *Zschr. f. rationelle Med.*, 1869, *34*.
124. MICHELSON, E.—*Untersuchungen über die Tiefe des Schlafes.* Dorpat, 1891, 8°. Also in *Psychol. Arb.*, Leipzig, 1897, *2*, 84–117.
125. MÖNNINGHOFF, O., AND PIESBERGEN, F.—Messungen über die Tiefe des Schlafes. *Zschr. f. Biol.*, München, 1883, *19*, 114–128.
126. REGELSBERGER, H.—Untersuchungen uber die Schlafkurve des Menschen. *Zschr. f. klin. Med.*, Berlin, 1928, *107*, 674–692. Also in *Verhandl. d. deutsch. Gesellsch. f. innere Med.*, München, 1927, *39*, Kong., 103.
127. SWAN, T. H.—A note on Kohlschütter's curve of the "depth of sleep." *Psychol. Bull.*, 1929, *26*, 607–610.

7. SEASONAL DIFFERENCES

128. BENEDICT, F. G., AND CARPENTER, T. M.—*Am. J. Physiol.*, 1928, *85*, 650.
129. BENEDICT, F. G., AND GUSTAFSON, FLORENCE L.—Seasonal variation in basal metabolism. *Am. J. Physiol.*, 1928, *86*, 1, 43.
130. BLEYER, A.—Periodic variations in the rate of growth of infants. *Arch. of Pediat.*, 1917, *34*, 366–371.

131. DEXTER, E. G.—*Weather influences.* New York: Macmillan, 1904.
132. MALLING-HANSEN.—See: Burk, F. D. Growth of children in height and weight. *Am. J. Psychol.*, 1897–1898, *9*, 253–290.
133. PORTER, W. T.—The seasonal variation in growth of Boston school children. *Am. J. Physiol.*, 1920, *52*, 121–131.
134. PORTER, W. T., AND BAIRD, P. C., Jr.—Weight and month of birth. *Am. J. Physiol.*, 1927, *81*, 1–5.
135. SCHMID-MONNARD, K.—Ueber den Einfluss der Jahreszeit und der Schule auf das Wachstum der Kinder. *Jahrb. f. Kinderhk.*, 1895, *40*, 84–107.
136. SCHUYTEN.—See: Peaks, A. G. Periodic variations in efficiency. *Educ. Psychol. Monog.*, 1921.

8. CHILDREN'S SLEEP

137. ANDREWS, J. M.—An investigation on the sleep of normal school students. *J. Educ. Psychol.*, 1911, *2*, 153–156.
138. ANON.—Ueber den Schlaf im Kindesalter. *Mtschr. f. Kind.*, 1923, *26*, 209.
139. ASCHAFFENBURG, G.—Der Schlaf im Kindesalter und seine Störungen. *Verhandl. d. Gesellsch. f. Kind.*, 1908, *5*, 260.
140. SAME.—*Verh. d. Gesellsch. dtsch. Naturforsch. u. Aertzte*, 1909, *80*, 343.
141. BÉNECH, JEAN.—Quelques troubles du sommeil chez les enfants des écoles. *Prat. méd. franc.*, Paris, 1929, *8*, 224–232. (Mai B, No. 5 bis.)
142. BERTOYE, P.—Sur un trouble rare du sommeil chez l'enfant; la Jactatio Capitis Nocturna. *Bull. Soc. de pédiat. de Paris*, 1927, *25*, 61–66.
143. BLATZ, W. E., AND BOTT, H. M.—*The management of young children.* New York: Morrow, 1930, pp. 366.
144. BOYNTON, M. A., AND GOODENOUGH, F. L.—The posture of nursery school children during sleep. *Amer. J. Psychol.*, 1930, *42*, 270–278.
145. CAMERON, H. C.—Sleep and its disorders in childhood. *Canad. Med. Assn. J.*, Toronto, 1931, *24*, 239–244. Also in *Brit. Med. J.*, London, 1930, *2*, 717–719.
146. CANESTRINI, S.—*Ueber das Seelenleben des Neugeborenen.* Berlin, 1913.
147. CASSEL.—Der Schlaf im Kindesalter. *D. m. W.*, 1906, 1457.
148. SAME.—Ueber den Schlaf des Kindes. *Zschr. f. Krankenflg.*, Berlin, 1911, *33*, 33–45.

149. Cramaussel, E.—Le sommeil d'un petit enfant. *Arch. de psychol.*, 1911, *10*, 321–326; *11*, 182–186.
150. Dukes, C.—Sleep in relation to education. *J. Roy. San. Inst.*, London, 1905, *26*, 41–44.
151. Fischer, E.—Kinderträume. Eine psychologische-padagogische Studie. Lfg. I. Stuttgart: Puttmann, 1928, pp. 64.
152. Fleming, B.—A study of the sleep of young children. *J. Am. Assn. Univ. Women*, 1925, *19*, 25–27.
153. Foster, J. C., Goodenough, F. L., and Anderson, J. E.—The sleep of young children. *J. Genetic Psychol.*, 1928, *35*, 201–217.
154. Garvey, C. R.—Children's sleep. In Valentine, *Readings in Psychology*. Harper's, 1931, pp. 262–266.
155. Heuyer, G.—Sleep in children. *J. méd. franc.*, 1926, *15*, 439–450.
156. Howland, J.—The chemical and energy metabolism of sleeping children. *Tr. Assn. Am. Physicians*, Philadelphia, 1911, *26*, 399–409.
157. Same.—The metabolism, directly determined, of healthy children during sleep. *Proc. Soc. Exper. Biol. & Med.*, New York, 1910–1911, *8*, 63–64.
158. Irwin, O. C.—The amount and nature of activities of newborn infants under constant external stimulating conditions during the first ten days of life. *Genet. Psychol. Monog.*, 1930, *8*, 1–92.
159. Johnson, H. M.—Sleep. In *Readings in Experimental Psychology*, ed. by W. L. Valentine. Harper's, 1931, pp. 262–266.
160. Karger, P.—Ueber den Schlaf des Kindes. *Beihefte zum Jahrb. f. Kinderhk.*, Berlin, 1925, Heft 5.
161. Peiper, A.—*Die Hirntätigkeit des Säuglings*. Berlin: Julius Springer, 1928, pp. 101.
162. Stern, W.—*Psychology of early childhood up to the sixth year of age*. Tr. by A. Barwell; 2nd ed., rev. and enl. New York: Holt; London: Allen & Unwin, 1930, pp. 623; 612.
163. Terman, L.—Le sommeil chez les écoliers. *Méd. scolaire*, 1922, *11*, 225.
164. Terman, L., and Hocking, A.—The sleep of school children. *J. Ed. Psychol. Monog.*, 1913, Mar., Apr., and May.
165. Same.—*The hygiene of the school child*, Chap. XX. Houghton Mifflin, 1914.

166. TRÖMNER.—Psychologie und Physiologie des Schlafes. *Neurol. Ctrbl.*, 1910. See also Das Problem des Schlafes, in Löwenfelds *Grenzfragen des Nerven- und Seelenlebens*.
167. WANG, C. C., AND KERN, RUTH.—The influence of sleep on basal metabolism in children. *Proc. Inst. Med.*, Chicago, 1927, *6*, 253.

9. DEPRIVATION

168. ASCHAFFENBURG, G.—Experimentelle Studien über Assoziationen, II. *Psychol. Arb.*, 1899, *2*, 1–83.
169. BARÈS, J.-M. P.—I. De la prolongation et la diminution du sommeil, sous le point de vue séméiologique; II. (etc.) Paris, 1839, 4°.
170. BAST, T. H., AND LOWENHART, A. S.—Studies in exhaustion due to lack of sleep. I. Introduction and Methods. *Am. J. Physiol.*, 1927, *82*, 121–126.
171. BAST, T. H., SCHACHT, F., AND VANDERKAMP, H.—Same. III. Effect on the nerve cells of the spinal cord. *Am. J. Physiol.*, 1927, *82*, 131–139.
172. BAST, T. H., AND BLOEMENDAL, W. B.—Same. IV. Effects on the nerve cells in the medulla. *Am. J. Physiol.*, 1927, *82*, 140–146.
173. BAST, T. H., SUPERNAW, S. S., LIEBERMAN, B., & MUNRO, J. —Same. Effect on thyroid and adrenal glands with special reference to mitochondria. *Am. J. Physiol.*, *85*, 135–140. See also reference 184 below.
174. DE MANACÉÏNE, MARIE.—Quelques observations expérimentales sur l'influence de l'insomnie absolue. Vortrag, gehalten auf dem internationalen medizinischen Congress in Rom, 1894. *Arch. ital. de biol.*, 1894, 322.
175. HERZ, FRANZ.—Selbstbeobachtung über Schlafentziehung. *Pflugers Arch.*, 1923, *200*, 429–442.
176. JOHNSON, H. M.—The real meaning of fatigue. *Harper's Magazine*, 1929, Jan., 1–8.
177. KLEITMAN, N.—Studies on the physiology of sleep. I. The effects of prolonged sleeplessness on man. *Am. J. Physiol.*, 1923, *66*, 67–92.
178. SAME.—V. Some experiments on puppies. *Am. J. Physiol.*, 1928, *84*, 386–395.
179. KROETZ, C.—Der Einfluss verlängerten Schlafentzugs auf den Blutchemismus beim Menschen. *Zentralbl. f. innere Med.*, Leipzig, 1926, *47*, 607.

180. Laird, D. A.—Effects of loss of sleep on mental work. *Indust. Psychol.*, 1926, *1*, 427.
181. Laird, D. A., and Wheeler, W., Jr.—What it costs to lose sleep. *Indust. Psychol.*, 1926, *1*, 694–695.
182. Laslett, H. R.—An experiment on the effects of loss of sleep. *J. Exper. Psychol.*, 1924, *7*, 45–58.
183. Same.—Experiments on the effects of loss of sleep. *J. Exper. Psychol.*, 1928. *11*, 370–398.
184. Leake, C., Grab, J. A., and Senn, M. J.—Studies in exhaustion due to lack of sleep. II. Symptomatology in rabbits. *Am. J. Physiol.*, 1927, *82*, 127–130.
185. Lee, M. A., and Kleitman, N.—Studies in the physiology of sleep: II. Attempts to demonstrate functional changes in the nervous system during experimental insomnia. *Am. J. Physiol.*, 1923, *67*, 141–152.
186. Legendre, R., and Piéron, H.—Du développement, au cours de l'insomnie expérimentale, de propriétés hypnotiques des humeurs en relation avec le besoin croissant de sommeil. *Compt. rend. Soc. de Biol.*, Paris, 1911, *70*, 190–192.
187. Same.—Recherches sur le besoin de sommeil consécutif à une veille prolongée. *Zschr. f. allg. Physiol.*, 1913, *14*, 235–262.
188. Moss, F. A., and others.—A study of experimental insomnia. *George Washington Univ. Bull.*, I, 1–24.
189. Patrick and Gilbert.—On the effects of loss of sleep. *Psychol. Rev.*, 1896, *3*, 469–483.
190. Petrova, M.—Prevention of sleep. The work of equibalancing the stimulating and inhibitory processes. (Also abstract in German.) In: Omeliansky & Orbeli: *Sbornik Pavlova*, Leningrad, 1924, *80*, 277–285.
191. Robinson, E. S., and Herrmann, S. O.—Effects of loss of sleep (I). *J. Exper. Psychol.*, 1922, *5*, 19–32.
192. Robinson, E. S., and Richardson, R. F.—Effects of loss of sleep (II). *J. Exper. Psychol.*, 1922, *5*, 93–100.
193. Roemer, E.—Tätigkeiten 3. *Internationalen Congress für Psychologie*, 1896.
194. Shirziraku, T.—Ueber den Einfluss der experimentellen Schlafstörung auf den Stoffwechsel. *Scient. Rep. Gov. Inst. Infect. Dis.*, Tokyo, 1925, *4*, 415–439.
195. Smith, May.—A contribution to the study of fatigue. *Brit. J. Psychol.*, 1916, *8*, 327–350.
196. Tobias, A.—Die Messung der Schlaflosigkeit. *Umschau*, Frankfort a.M., 1926, *30*, 450.

197. WEISKOTTEN, T. F.—On the effects of loss of sleep. *J. Exper. Psychol.*, 1925, *8*, 363–385.
198. WEISKOTTEN, T. F., AND FERGUSON, J. E.—A further study of the effects of loss of sleep. *J. Exper. Psychol.*, 1930, *13*, 247–266.
199. WHITING, H. F., AND ENGLISH, H. B.—Fatigue tests and incentives. *J. Exper. Psychol.*, 1925, *8*, 33–49.
200. WUTH, O.—Ueber den Säurebasenhaushalt im Schlaf bei Schlaflosigkeit und im Schlafmittelschlaf. *Zschr. f. d. ges. Neurol. u. Psychiat.*, Berlin, 1928–1929, *118*, 447–450.

10. EFFECTS OF COFFEE AND DRUGS

201. DARROW, C. W.—The psychological effects of drugs. *Psychol. Bull.*, 1929, *26*, 527–545.
202. FETTERMAN, J. C., SHILLINGER, M. L. C., AND IRVIN, R. R.—Coffee and milk drinking habits of school children. *Nation's Health*, 1927, *9*, 31; 72.
203. FÜRBINGER.—Der Einfluss des Kaffees auf den Menschlichen Organismus. *Zschr. f. ärtztl. Fortbild.*, Jena, 1930, *27*, 79–81.
204. GESSER, H.—Ueber den Koffeingehalt von Kaffeeauszügen und deren physiologische Wirkung. *Zschr. f. Untersuch. d. Lebensmitt.*, Berlin, 1926, *3*, 389–392.
205. HOLLINGWORTH, H. L.—The influence of caffein alkaloid on the quality and amount of sleep. *Am. J. Psychol.*, 1912, *23*, 89–100.
206. SAME.—The influence of caffein on mental and motor efficiency. *Arch. Psychol.*, 1912, *22*, pp. vi+166.
207. SAME.—The influence of caffein on the speed and quality of performance in typewriting. *Psychol. Rev.* 1912, *19*, 65–72.
208. IRVIN, R. R.—Hygienic aspects of coffee. *Med. J. & Rec.*, New York, 1927, *126*, 410; 481; 549.
209. KEESER, E. AND J.—Determining the presence of caffein, morphine, and barbaturic acid derivatives in the brain; their action on sleep centers. *Arch. f. exper. Path. u. Pharmakol.*, *127*, 230–235, 1928.
210. LAPIQUE, M.—Action de cafeine sur l'excitabilité de la moelle. *C. R. Soc. de Biol.*, 1913, *74*, 32–34.
211. LEHMANN, K. B., AND WEIL, H.—Vergleichende Versuche über die Wirkung von Kaffee und Tee. *Arch. f. Hygiene*, 1923, *92*, 85–88.

212. Macht, D. I., Bloom, W., and Ting, G. C.—Comparative study of ethanol, caffein, and nicotine on the behavior of rats in a maze. *Am. J. Physiol.*, 1921, *56*, 264.

213. Maier, H. W.—Allgemeines zur zentralen Cocainwirkung auf den Menschen. *Schweiz. med. Woch.*, 1925, *55*, 13–15.

214. Meyer, M. F.—The psychological effects of drugs. *Psychol. Bull.*, 1922, *19*, 173–182.

215. Molinéry, R.—Treatise by M. B. Moseley on properties and effects of coffee. *Bull. soc. franc. d'hist. de la méd.*, 1927, *21*, 90–96; also Paris méd. (supp.), 1927, *1*, 353–355.

216. Poffenberger, A. T., Jr.—Psychological effects of drugs. *Psychol. Bull.*, 1916, *13*, 434–436.

217. Powers, H.—The syndrome of coffee. *Med. J. & Rec.*, New York, 1925, *121*, 745–747.

218. Schulte, Robt. W.—Der Einfluss des Kaffees auf Körper und Geist; experimentelle Untersuchungen und Beobachtungen über die psycho-physiologische Wirkung von Koffeinhaltigem und Koffeinfreiem Kaffee. Unter Mitwirkung von Joh. Müller und C. Kupsch. Dresden, 1929, 101 [I] pp., 4°.

219. Taylor, C. K.—Effect of coffee drinking upon children. *Psychol. Clinic*, 1912, *6*, 56–58.

11. Visual Flicker

220. Adrian, E. D., and Mathews, R.—The action of light on the eye. I. The discharge of impulses in the optic nerve and its relation to the electrical changes in the retina. *J. Physiol.*, 1927, *63*, 378–414.

221. Same.—The action of light on the eye. II. The processes involved in retinal excitation. *J. Physiol.*, 1927–1928, *64*, 279–301.

222. Same.—The action of light on the eye. III. The interaction of retinal neurons. *J. Physiol.*, 1928, *65*, 273–298.

223. Allen, Frank.—Some phenomena of the persistence of vision. *Physical Rev.*, 1909, *28*, 45–56.

224. Same.—On reflex visual sensations. *J. Opt. Soc. Amer.*, 1923, *7*, 583–626.

225. Baader.—Ueber die Empfindlichkeit des Auges gegen Lichtwechsel. Freiburg. Dissertation, 1891.

226. Bills, M. A.—The lag of visual sensation in its relation to wave-length and intensity of light. *Psychol. Monog.*, 1920, *28*, *127*, 101 pp.

227. COBB, P. W., AND GEISSLER, L. R.—The effect on foveal vision of bright surroundings. *Psychol. Rev.*, 1913, *20*, 425–447.
228. COBB, P. W.—Influence of pupillary diameter on visual acuity. *Am. J. Physiol.*, 1915, *36*, 335–346.
229. COBB, P. W., AND LORING, M. W.—A method of measuring retinal sensitivity. *J. Exper. Psychol.*, 1921, *4*, 175–197.
230. COBB, P. W.—The relation between field brightness and the speed of the retinal impression. *J. Exper. Psychol.*, 1923, *6*, 138–160.
231. FERRY, E. S.—Persistence of vision. *Amer. J. Sci.*, 1892, *44*, 192–207.
232. GRANIT, R.—Comparative studies on the peripheral and central retina. *Am. J. Physiol.*, 1930, *94*, 41–50.
233. HELMHOLTZ, H. L.—*Treatise on physiological optics*, tr. from 3d German ed., ed. by J. P. C. Southall. Opt. Soc. Amer., 3 vols.
234. HYDE.—*Bull. Bur. Standards*, 1906, *2*, 1.
235. IVES, H. E.—Studies in the photometry of lights of different colors. II. Spectral luminosity curves by the method of critical frequency. *Phil. Mag.*, 1912, *24*, 352–370.
236. IVES AND KINGSBURY.—The theory of the flicker photometer. II. Unsymmetrical conditions. *Phil. Mag.*, 1916, *31* (6th series), 290–322.
237. IVES, H. E.—Critical frequency relations in scotopic vision. *J. Opt. Soc. Amer.*, 1922, *6*, 254–268.
238. SAME.—A theory of intermittent vision. *J. Opt. Soc. Amer.*, 1922, *6*, 343–361.
239. KENELLY, A. E., AND WHITING, S. E.—The frequencies of flicker at which variations in illumination vanish. National Elect. Light Assn., 1907 convention, Vol. 1, 327–342.
240. KOFFKA, K.—*Growth of mind.* Tr. by Ogden. London: Kegan, Paul, Trench, Trubner & Co., Ltd.; New York: Harcourt, Brace, 1924, Chap. III.
241. LUCKIESH, M.—On the growth and decay of color sensations in flicker photometry. *Physical Rev.*, N.S., 1914, *4*, No. 1.
242. LYTHGOE, R. J., AND TANSLEY, K.—The relation of critical frequency of flicker to the adaptation of the eye. *Proc. Royal Soc.*, London (B), 1929, *105*, 60–92.
243. NAGEL.—*Handbuch der Physiologie des Menschen.* Braunschweig. Vol. III, p. 254.
244. PFUND, A. H.—On the use of the rotating sector in photometry. *Psychol. Rev.*, 1914, *21*, 116–120.

245. Plateau.—Dissertation sur quelques propriétés des impressions produites par la lumière sur l'organ de la vue. Liège, 1829.

246. Polikarpoff, M.—Ueber die experimentelle Prüfung des Lasareff-Gesetzes der Verschmelzung der Flimmerungen beim peripherischen und zentralen Sehen in monochromatischen Lichte. *Archiv. f. d. ges. Physiol.* (Pflüger), 1926, *215*, 95–102.

247. Porter, T. C.—Contributions to the study of "flicker." *Proc. Royal Soc.*, 1898, *63*, 347–356.

248. Same.—Contributions to the study of "flicker," II. *Proc. Royal Soc.*, 1902, *70*, 313–329.

249. Reeves.—The response of the average pupil to various intensities of light. *Trans. Illuminating Eng. Soc.*, 1921, *16*, 78.

250. Schaterinkoff, M.—Ueber den Einfluss der Adaptation auf die Erscheinung des Flimmerns. *Zschr. f. Psychol. u. Physiol. usw.*, 1902, *29*, 241–252.

251. Sherrington, C. S.—On reciprocal action in the retina as studied by means of rotating discs. *J. Physiol.*, 1897, *21*, 33–54.

252. Same.—On binocular flicker. *Brit. J. Psychol.*, 1904–1905, *1*, 26–60.

253. Soltmann.—Ueber einige physiologische Eigentümlichkeiten der Muskeln und Nerven der Neugeborener. *Jahrb. f. Kinderhk.*, 1878, *12*.

254. Troland, L. T.—The theory and practice of the artificial pupil. *Psychol. Review*, 1915, *22*, 167–176.

255. Same.—*The principles of psycho-physiology: Vol. II, Sensation.* New York: van Nostrand, 1930.

INDEX